CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

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NOVEMBER, 1955. **Vol. L, No. 11**

FIFTIETH YEAR OF PUBLICATION

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LEADING CONTENTS

	PAGE
Concrete Roads	379
Determination of Constants for Non-prismatic Beams by the Moment Distribution Method. *By A. Chronowicz*	381
Concrete and Structural Form	387
Analysis of Frames by the Nomographic Method. *By J. Rygol*	394
Book Reviews	404
Precast Concrete in an Office Building	405
Precast "Shell" Roofs	408

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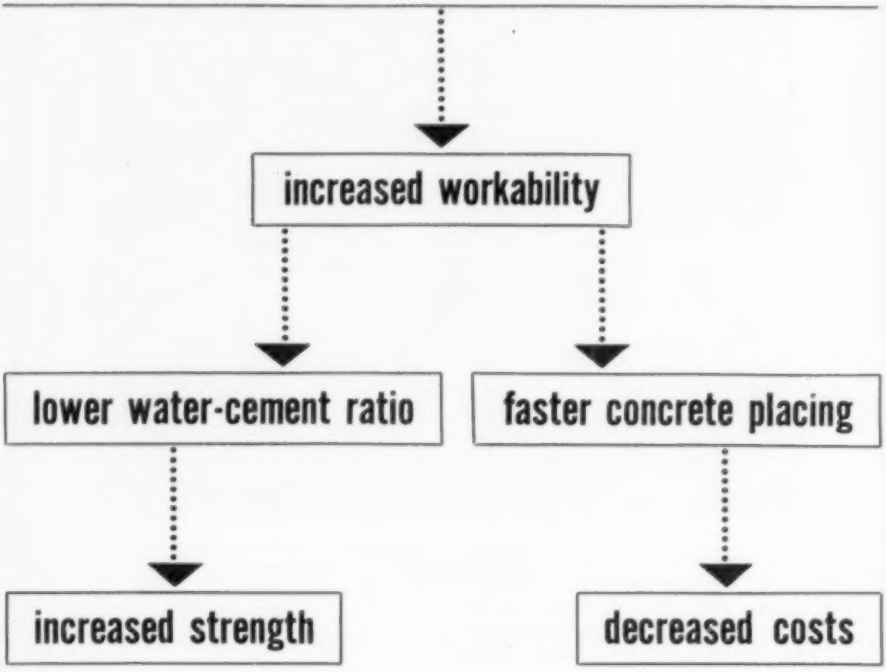

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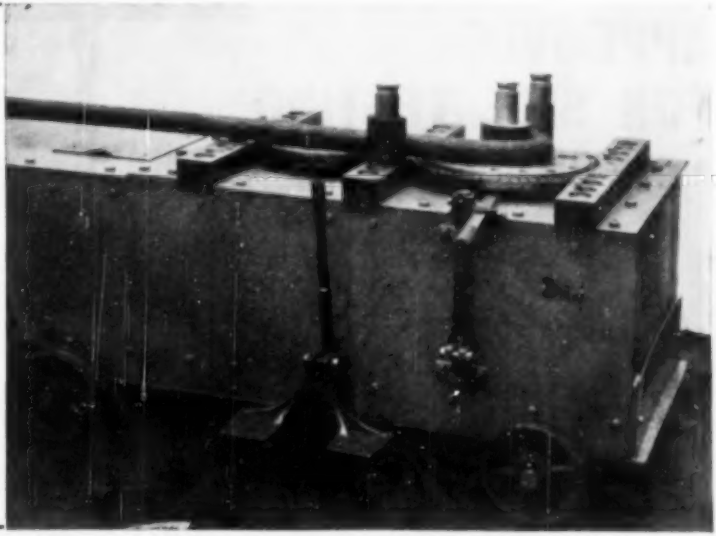

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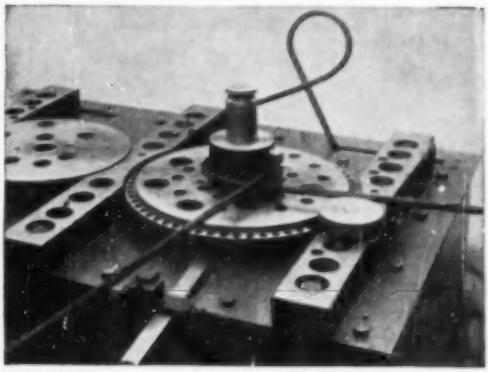

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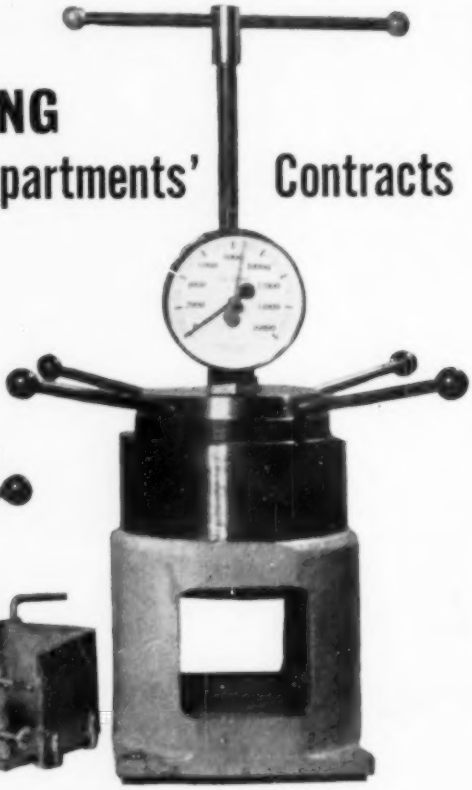

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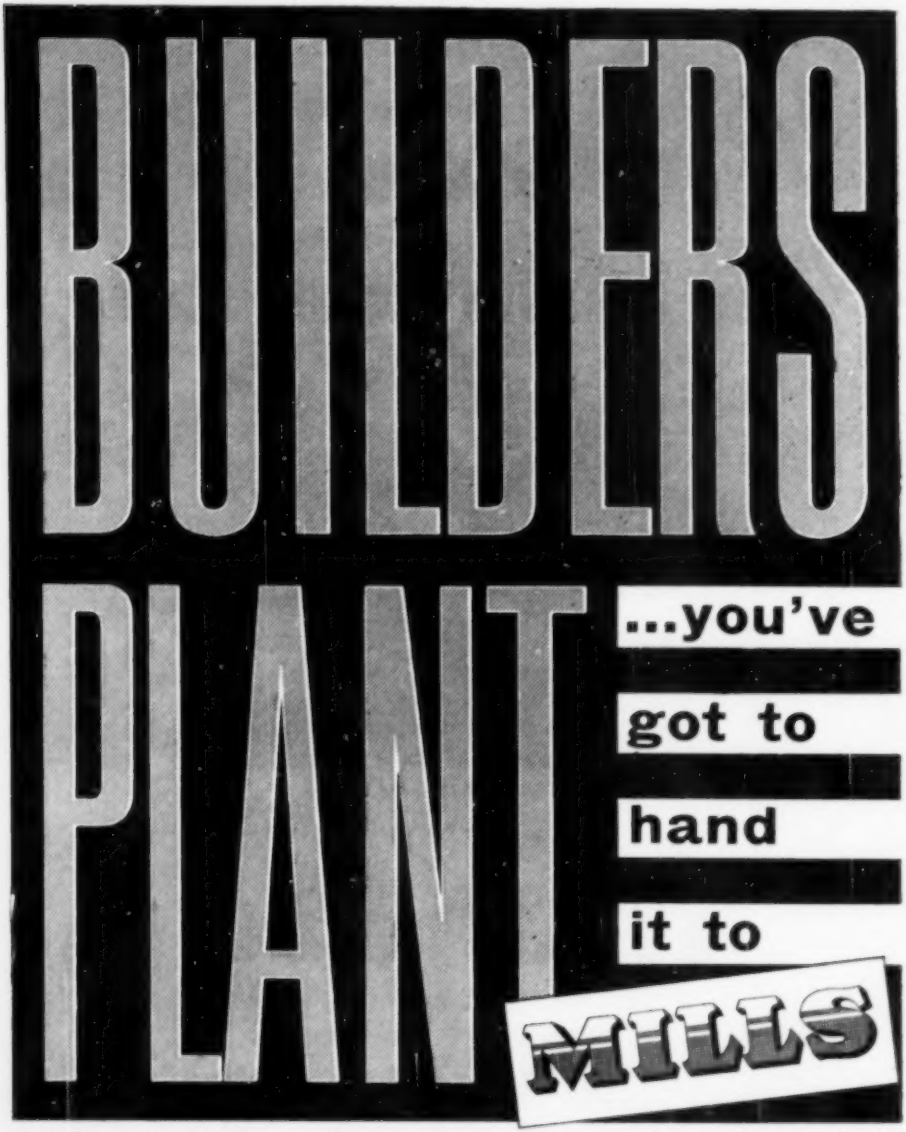

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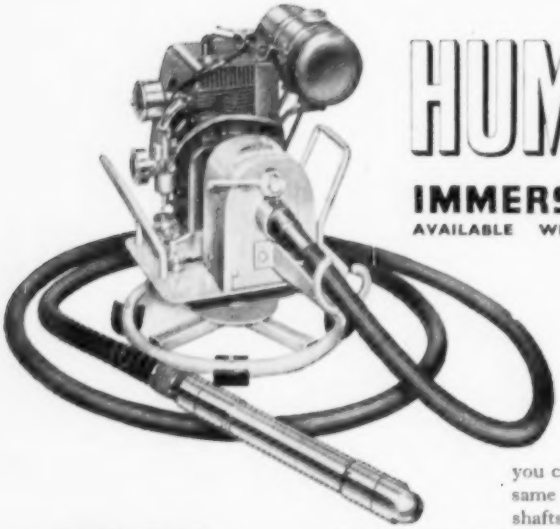

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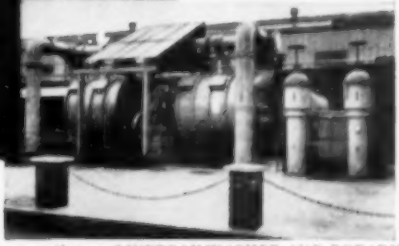

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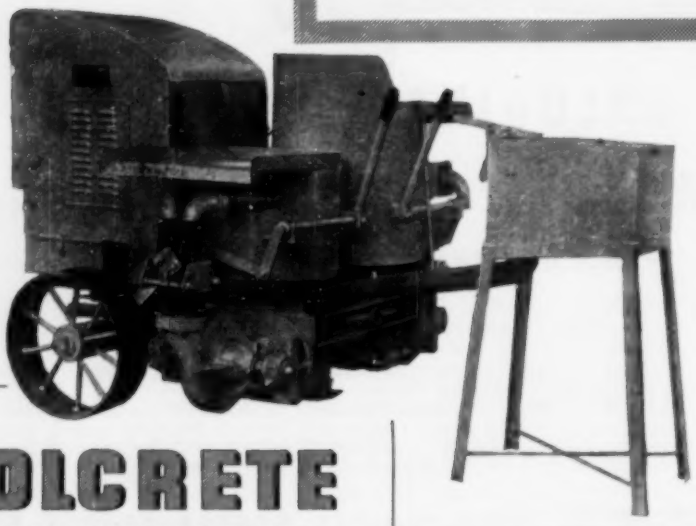

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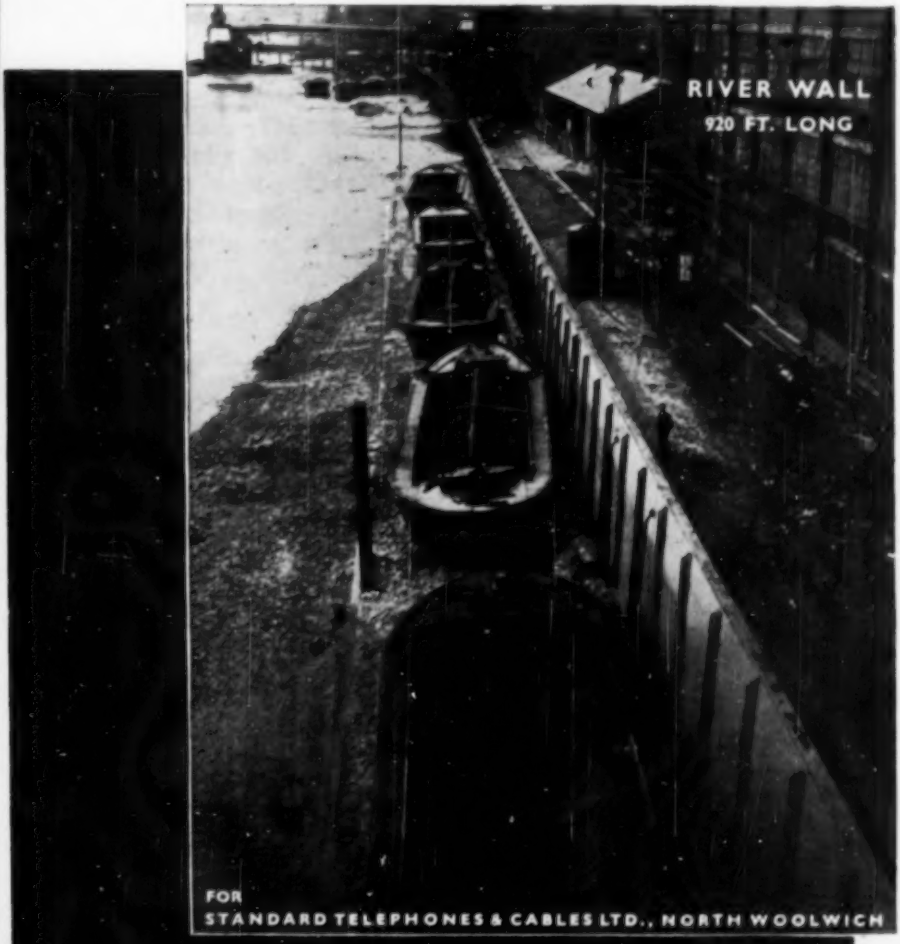

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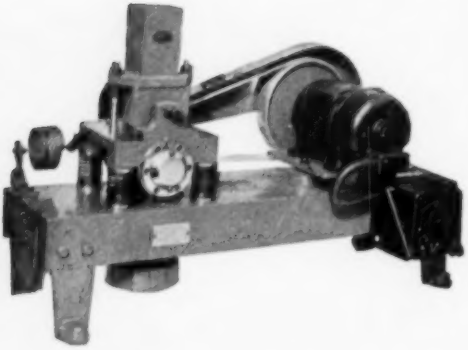

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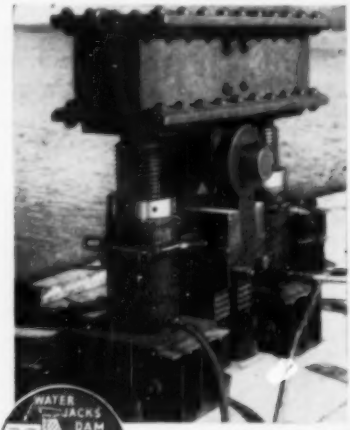

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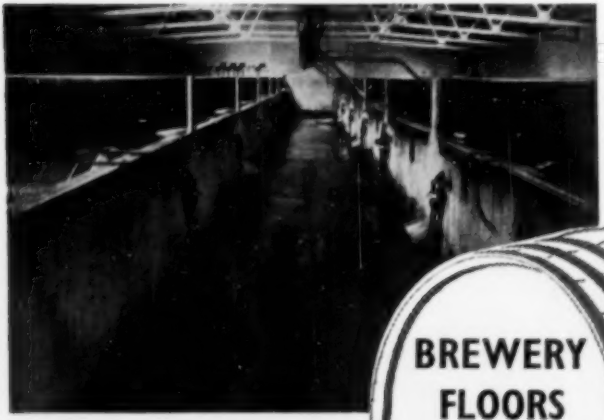

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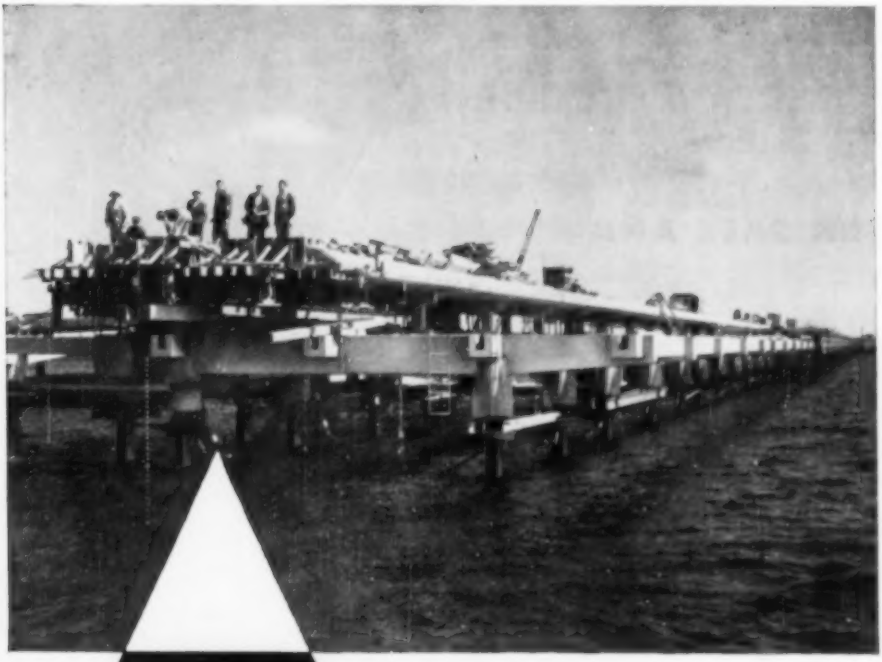

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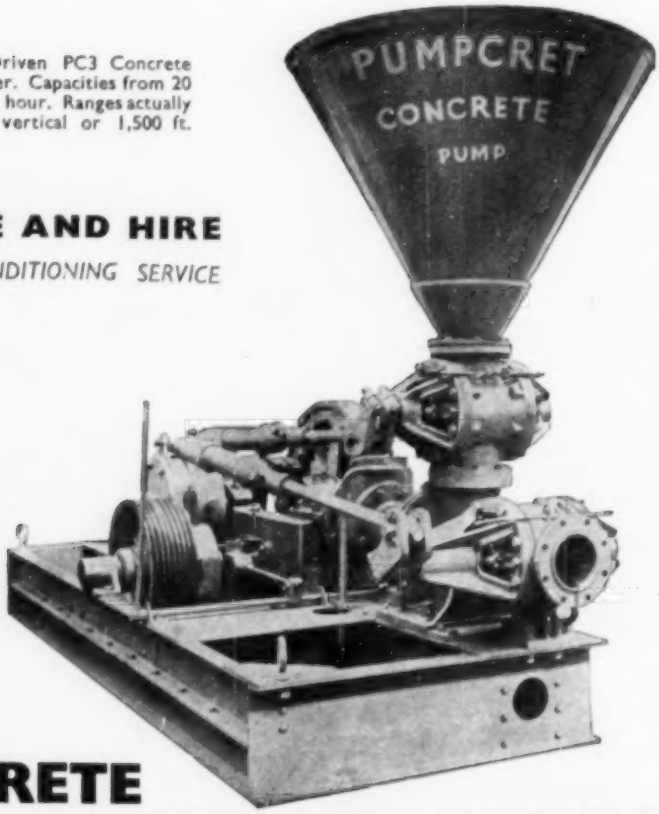

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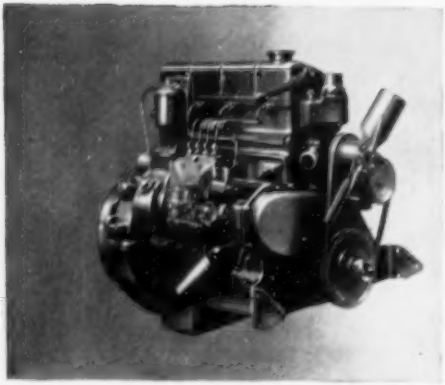

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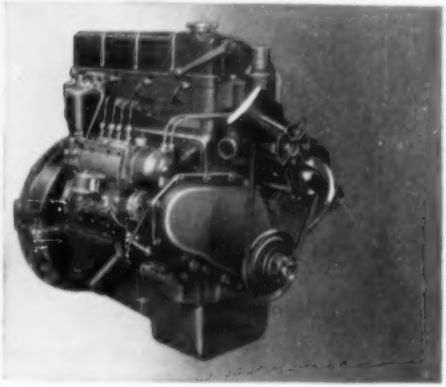

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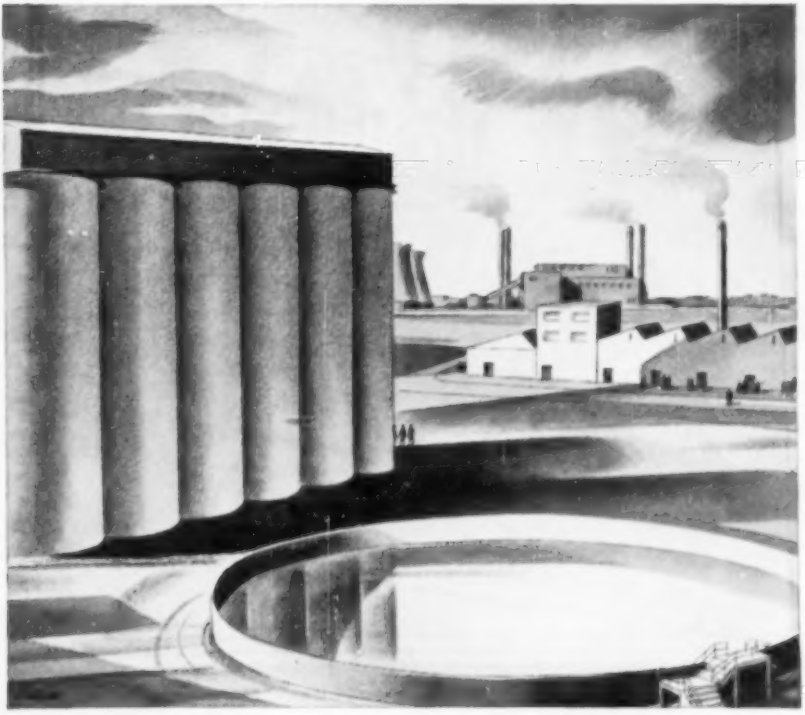

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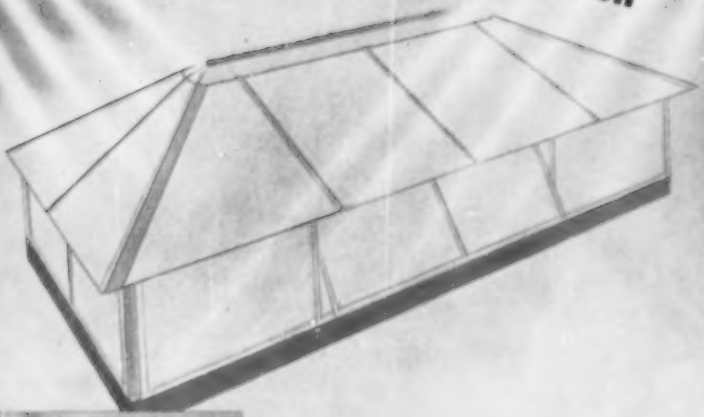

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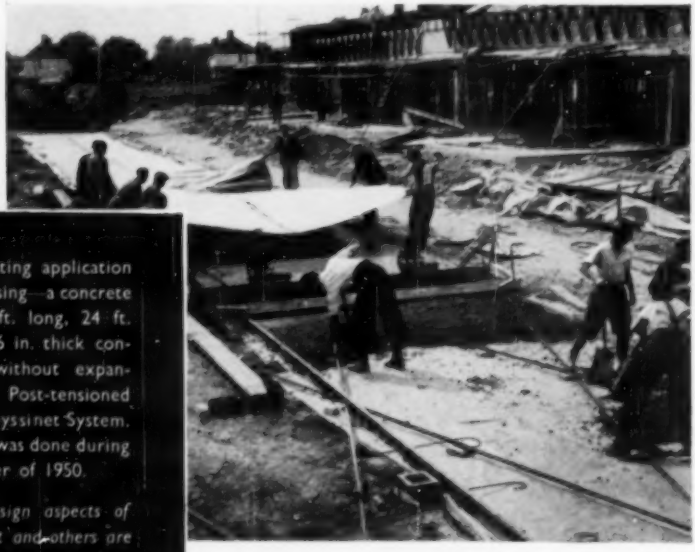

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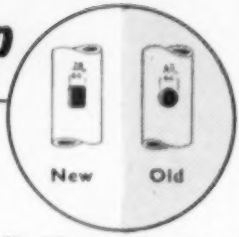
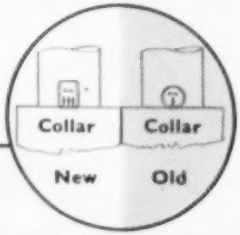
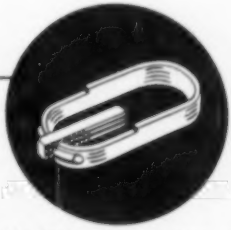


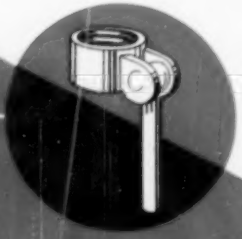
The "Squarepin" requires a smaller hole thus giving a greater cross-sectional area of tube.



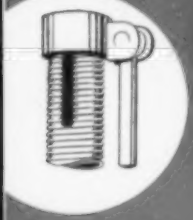
"Dig-in" under load is eliminated by the "Squarepin" which has an increased bearing area reducing the stress on the tube and collar.



No loose pin — No chain to break. The "Squarepin" is an integral part of the shroud.



Drop forged handle gives greater operational strength.



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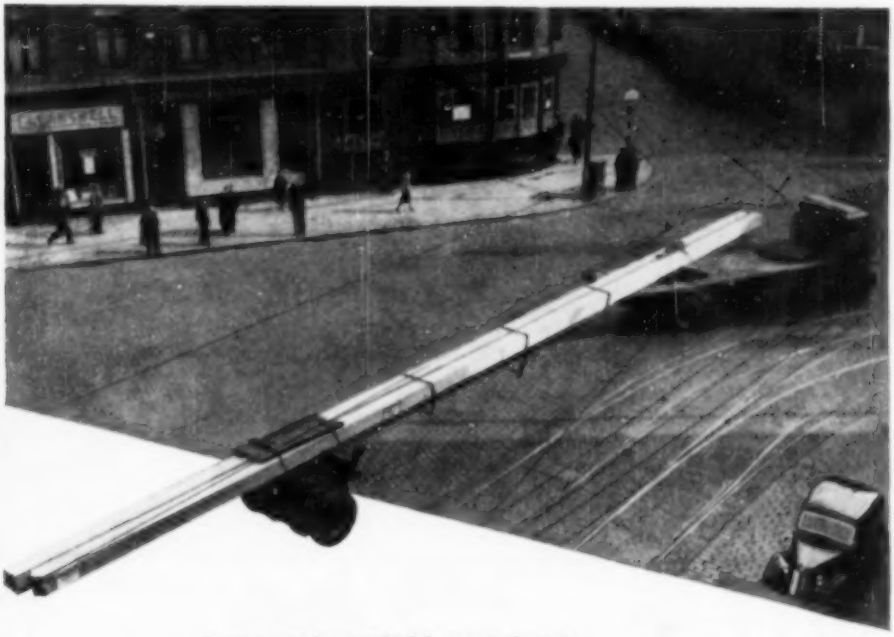

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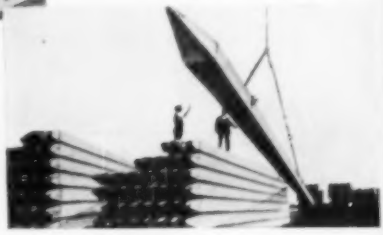

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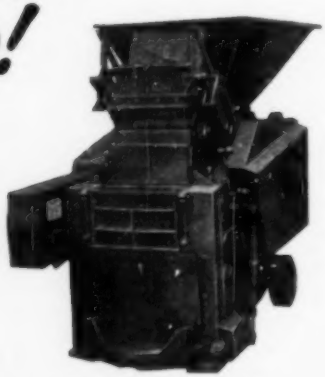

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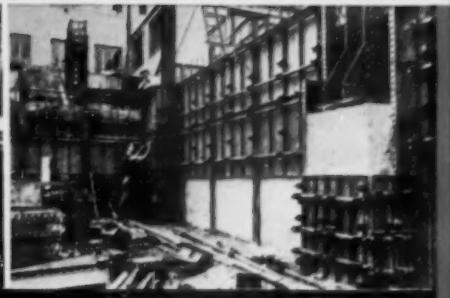

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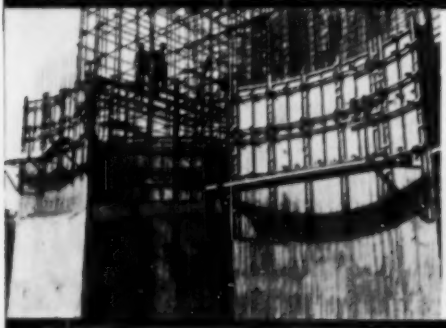

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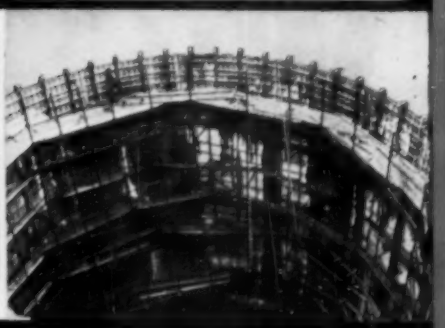

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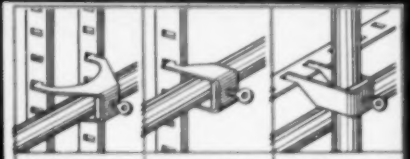

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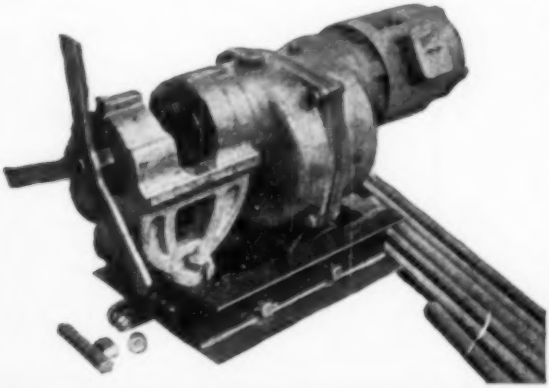

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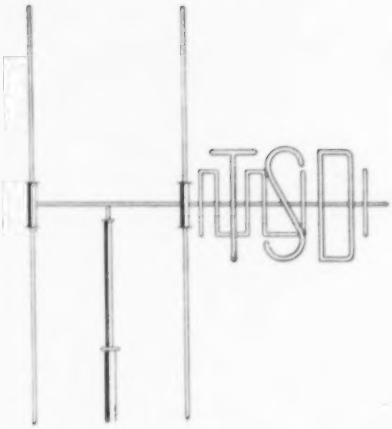

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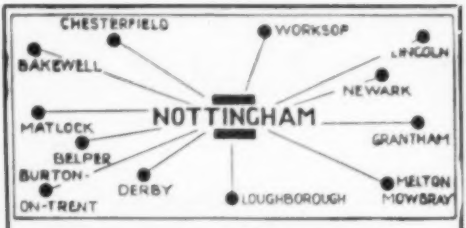

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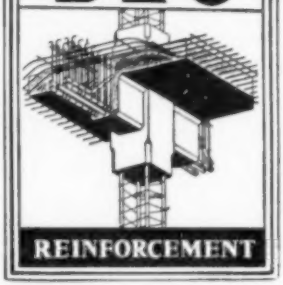

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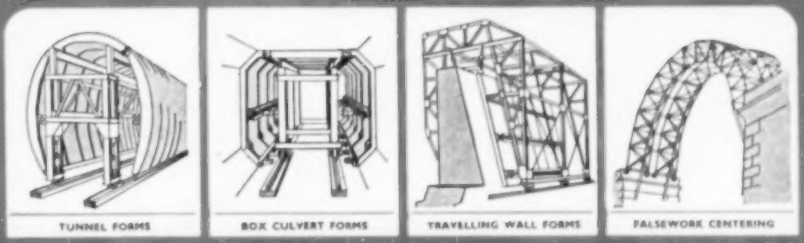

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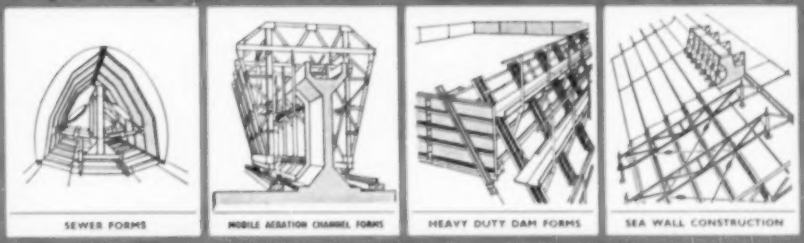

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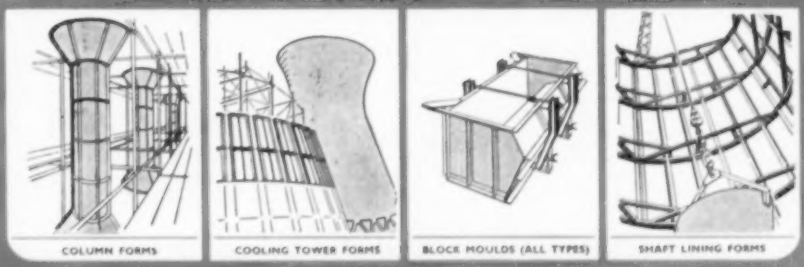

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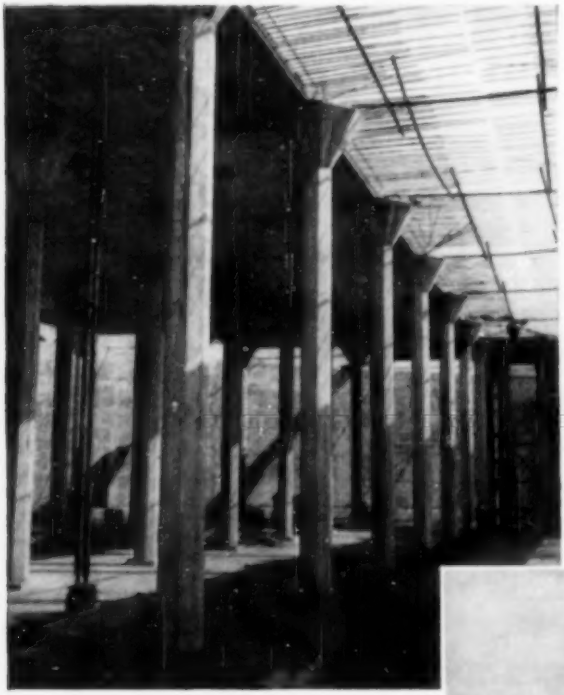

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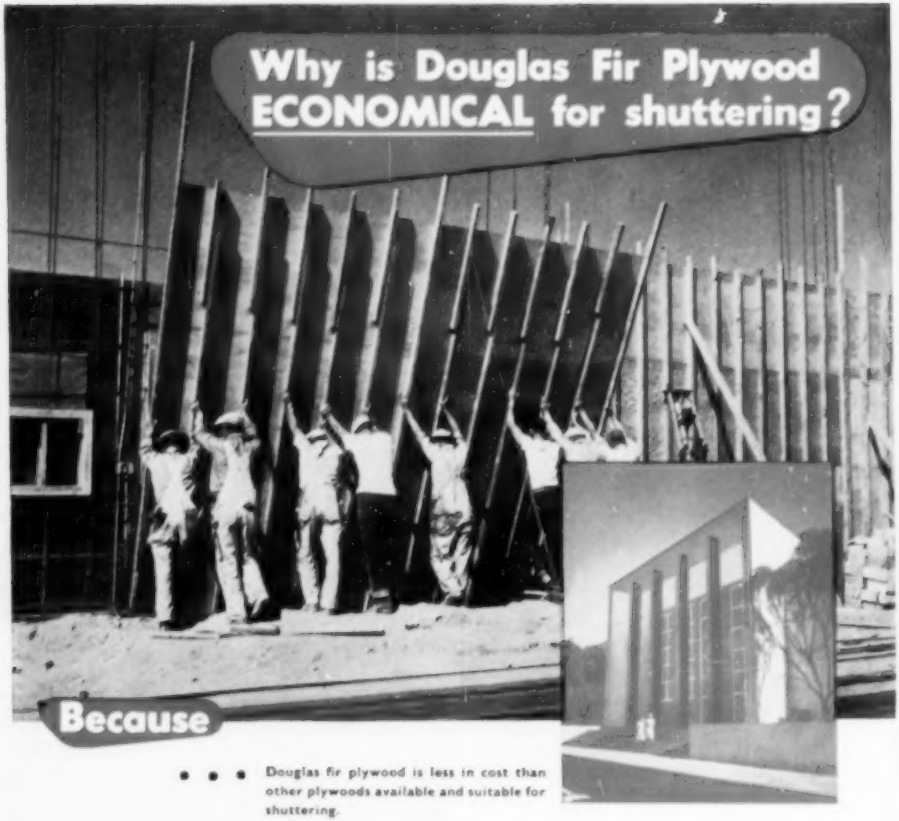

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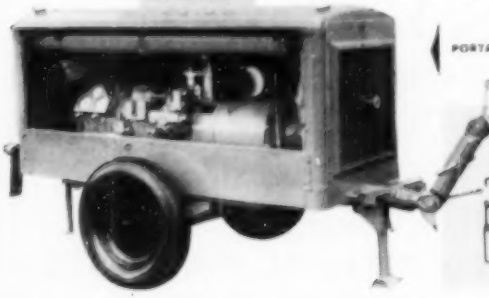

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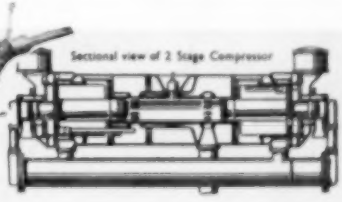

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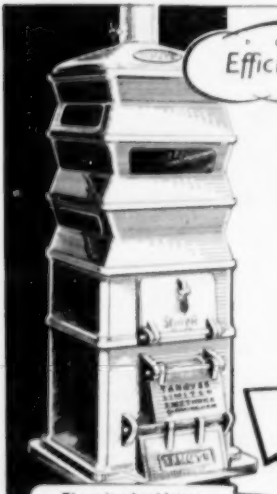

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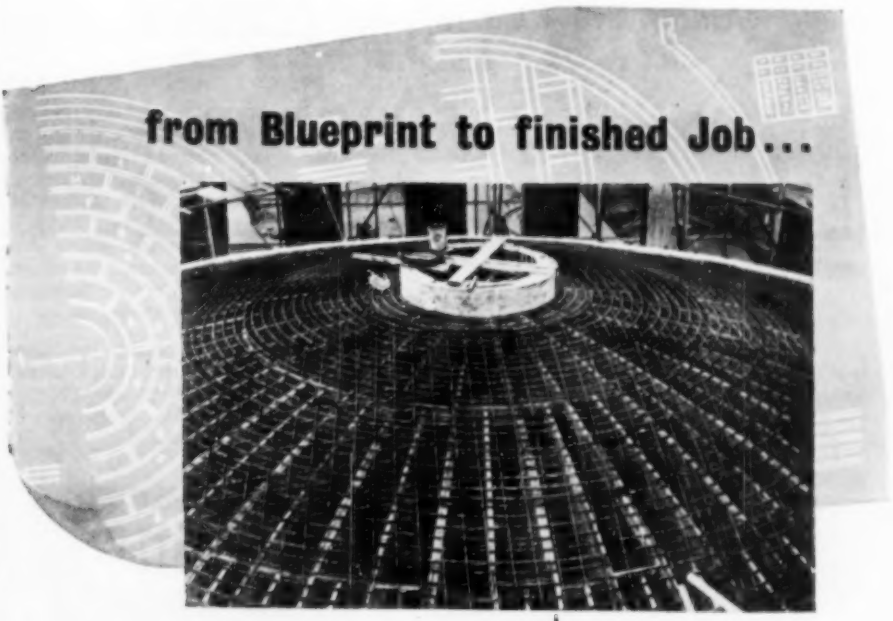

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Volume L, No. 11. LONDON, NOVEMBER, 1955.

EDITORIAL NOTES

Concrete Roads.

APART from the volume and weight of traffic and the nature of the soil, concrete roads built to the same design may, as in the case of other concrete work, be good or bad or indifferent according to the climatic conditions, the state of the weather when the work is done, the quality of the workmanship, the type of cement, and the firmness, uniformity, and drainage of the soil beneath the slab. Much information has been published on the design and performance of concrete roads in different parts of the world, but most of it is of little use without more information than is given, or can be given. We are told the thickness of the slab, and must assume that it is maintained throughout the length of the road. The amount and position of the reinforcement, if any, is stated, and it has to be assumed that they are the same throughout. We know the specified ingredients of the concrete, but not how strictly these are adhered to. The nature of the aggregate may be stated, but not its suitability for making strong and durable concrete ; for example, to say that a certain stone was used is meaningless unless we know whether it was hard or soft, and we do not know whether the aggregate had alkali-reactive properties. We may know whether a road-making machine was used for consolidating the slab, but we are seldom told the type of machine or whether it was properly used. The geological formation is generally stated, but whether the same stratum is immediately under the road throughout its length is seldom mentioned. We may be given an idea of the specified degree of compaction of the soil under the slab, but there is no means of knowing whether this was sufficient or if it was uniform throughout. The weather conditions when the road was laid are not known, yet a sudden downpour of rain will nullify the most carefully-arranged water-cement ratio and a sudden frost can damage unprotected freshly-laid concrete. Whether the cement was fine or coarse is seldom stated ; the importance of this has been realised in Germany for many years, and the success of the roads laid between the wars is largely attributed to the use of coarse cement. We are often told the average compressive strength of cubes tested when a road is built, but not the highest and lowest strengths or whether the average is arrived at by some form of statistical juggling in which the weakest and the strongest results are omitted.

The foregoing possibilities of variations in the strength and stability of concrete roads are some of the factors that are no doubt responsible for the contradictory results of the behaviour of concrete roads that appear in most

reports. Roads of the same or of varying thicknesses, reinforced or not reinforced, and with joints at long or close intervals, are reported as being successful or unsuccessful in different parts of a country or in different countries, and in some cases parts of the same road are in good condition and others in bad condition. These differences are obviously due as much, or more, to differences in workmanship than to the design. A report * just published on concrete roads in Belgium and Germany resembles most other reports on concrete roads in that it does not always give sufficient information to make it really useful. For example, it is stated that in Germany some slabs 6 in. thick in one district have given as good results as slabs 9 in. and 10 in. thick in other districts, but no details are given of the amount of reinforcement, if any, or the spacing of the joints, or the nature of the soil, or the quality of the work. Some prestressed slabs laid in 1953 are stated to have cracked, but no details are given of the amount or position of the prestressing steel or of the strength of the concrete or the compression produced in the concrete.

The report contains an interesting account of the performance of unreinforced roads, with widely-spaced expansion joints, in Belgium, where this type of construction has been used for a number of roads. The concrete has a compressive strength of 8500 lb. per square inch at fifty-six days, and the resulting high strength in bending is thought to have an influence on the comparative freedom from transverse cracking in these roads. Rapid-hardening cement is used with crushed hard stone or gravel and siliceous sand. Continuously-graded aggregate of 1½ in. maximum size and gap-graded aggregate of 2½ in. maximum size are used, generally in the proportions of 1 part cement to 5 or 6 parts of aggregate. In some cases still richer mixtures are used, but it does not seem that the rich mixtures result in slippery surfaces. The transverse joints are from 26 ft. to 50 ft. apart; they are formed by a machine that forces a vertical blade into the wet concrete, and the groove is filled with a strip of jointing material. Longitudinal joints are plain butts without tie-bars; one face of the joint is painted with bitumen. The slabs are laid on a layer of sand about an inch thick spread on the compacted soil. On the motor-road from Brussels to Ostend the equipment used makes possible the concreting of 570 ft. of road 25 ft. wide per day, but the length of the working day and the duration of stops for meals are not stated.

A curious statement is attributed to a German engineer who is reported to have said that slabs 9 in. thick (10 in. on embankments) are used because experience has proved that these thicknesses are best, and that "we are still making tests and mathematical calculations to prove that our practical decisions are right". This may be an error of translation, for it is inconceivable that, by analogy, an engineer would not believe that he had been out in the rain until tests of his clothing and mathematical computations were available to prove that he had indeed done so. It is, however, refreshing to see that only once in this report does the Road Research Station call a road a pavement, as in so many of its previous publications; except for the one slip a road is here called a road or a carriageway, so that our road-safety organisations will not have to exhort us to beware of "Death on the Pavement", or to instruct children to keep off the pavement.

* Concrete Roads in Belgium and Western Germany. 1954. Road Research Technical Paper No. 35. (H.M. Stationery Office. Price 3s.)

Determination of Constants for Non-prismatic Beams by the Moment-distribution Method.

By A. CHRONOWICZ.

THE frame illustrated in *Fig.* 1 represents a typical industrial structure designed to carry cranes travelling on beams, so that there is a reduction in the size of the columns above the crane-beams. The elastic constants of such columns must be determined before an analysis of the complete frame may be made. These constants, consisting of stiffness factors, carry-over factors, fixed-end moments, and moments due to arbitrary displacements can be calculated by the method of moment distribution.

The stiffness S of the beam is defined as the moment producing unit rotation at the end of the beam. In the case of the prismatic member the value of this moment is $S = 4\frac{I_0}{L}$. This moment will also produce unit rotation of the end B of the column XB if it is assumed to be fixed at X, and the constant $\frac{I_0}{L}$ is calculated regarding XB as an independent span (*Fig.* 2).

By restraining the end B against further rotation and balancing the resulting fixed-end moment at X, and also introducing any required corrections for sway, the final moment at B is the moment producing unit rotation of the column AB at the joint B; this moment is therefore the stiffness S_{BA} of the column AB at B. The value of this moment can be then expressed in terms of the moment of inertia I_0 of the reduced cross section of the column (*Fig.* 2).

M^0 denotes moments under propped conditions while Q^0 is the reaction due

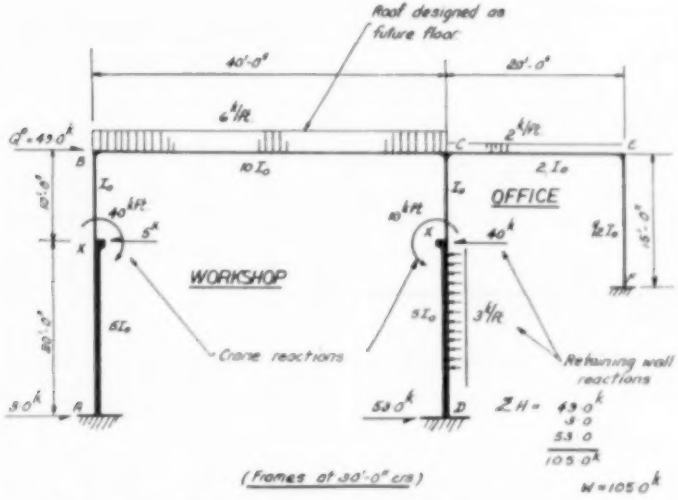
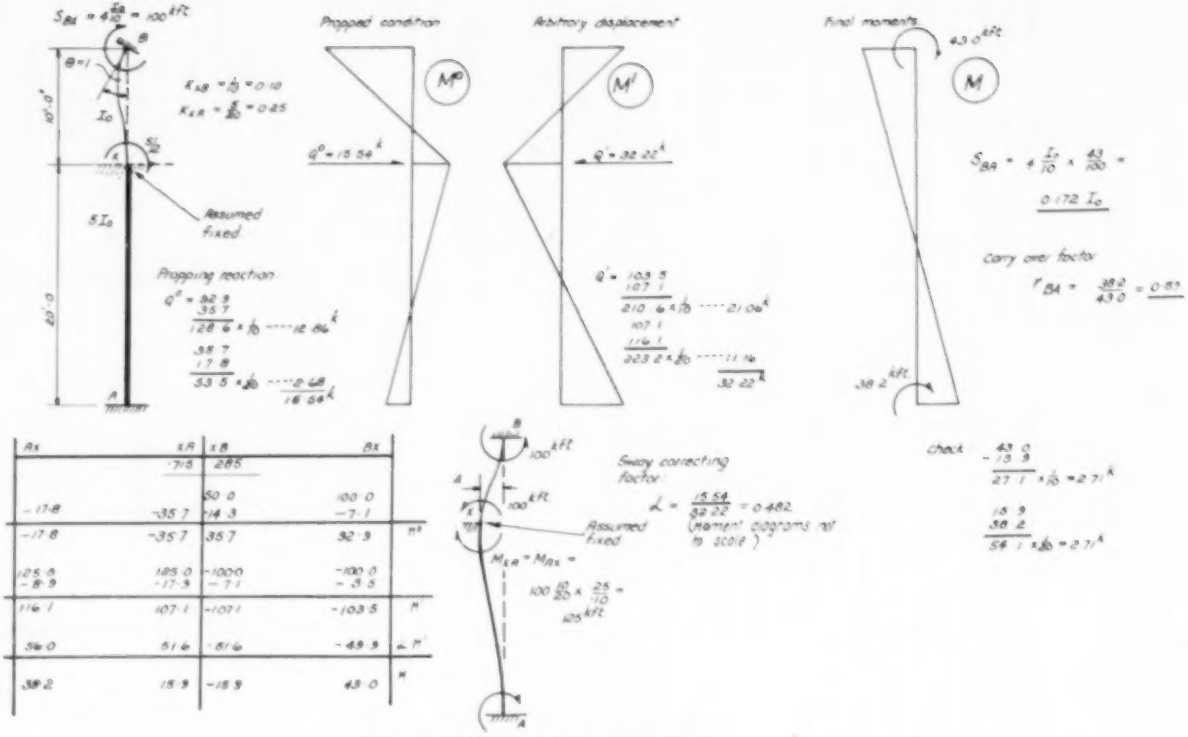


Fig. 1.—Dimensions, Loading, and Static Reactions.



	Ax	xA	xB	Bx	
		0.718	2.85		
Propped conditions	-17.8	-35.7	50.0 14.3	100.0 -7.1	M
	-17.8	-35.7	35.7	92.9	
Arbitrary sway	125.0 -8.9	125.0 -17.9	-100.0 -7.1	-100.0 -3.5	M
	116.1	107.1	-107.1	-103.5	
Corrected sway	56.0	51.6	-51.6	-49.9	ΔM
Final moments	38.2	15.9	-15.9	43.0	M

Fig. 2.—Stiffness of Member B–A.

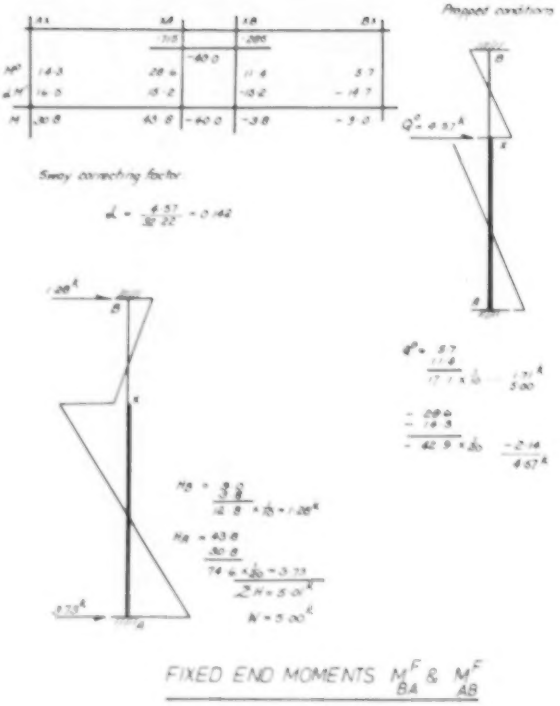

Propped conditions
Sway correcting factor
FIXED END MOMENTS M^F_{BA} & M^F_{AB}

Fig. 3.

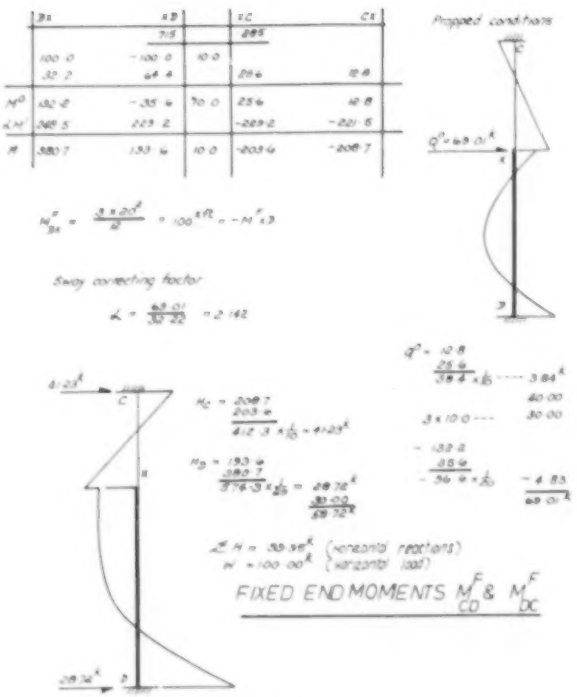

Propped conditions
Sway correcting factor
FIXED END MOMENTS M^F_{CD} & M^F_{DC}

Fig. 4.

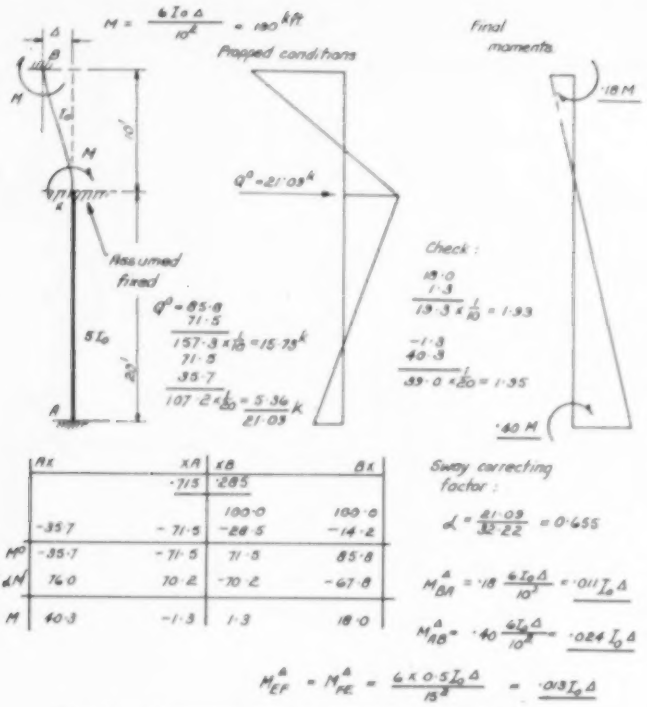


Fig. 5.—Moments due to Arbitrary Displacement.

to the props. M' denotes the assumed moments due to arbitrary displacement of joint X, Q' is the resulting displacing force, α is the ratio $\frac{Q^0}{Q'}$, and M denotes the final moments after correction for sway.

The carry-over factor r_{BA} is determined by the ratio $\frac{M_{AB}}{M_{BA}}$, which is the ratio of the moment produced at one end of the member due to the moment at the other end. In a similar manner the fixed-end moments may be found (*Figs.* 3 and 4).

Moments due to the arbitrary displacement of joint B, which are required for the correction for sway of the complete frame, may also be found by stages in terms of I_0, assuming joint B to be fixed (*Fig.* 5).

An illustration of the analysis of the composite structure illustrated in *Fig.* 1 is given in *Figs.* 6 to 9. *Fig.* 6 shows the elastic constants, the fixed-end moments, and the moment-distribution table for the propped condition (lateral translation of beam BCE is prevented). The diagram of the moments M^0 at this stage is shown in *Fig.* 7; this shows also the moments M' due to arbitrary displacement of beam BCE, while the actual distribution of these moments is indicated in *Fig.* 8. The final moments M (*Fig.* 9) are the sum of $M^0 + \alpha M'$.

Fixed end moments: $M^F_{BC} = -\frac{6 \times 40^2}{8} = -800.0^{kft}$

$M^F_{CB} = 800.0^{kft}$

$M^F_{CE} = -\frac{8 \times 20^2}{12} = -66.7^{kft}$

$M^F_{EC} = 66.7^{kft}$

Stiffness:

$S_{BC} = S_{CB} = 4\frac{10I_0}{40} = 1.0I_0 \quad 2S_B = 1.0$

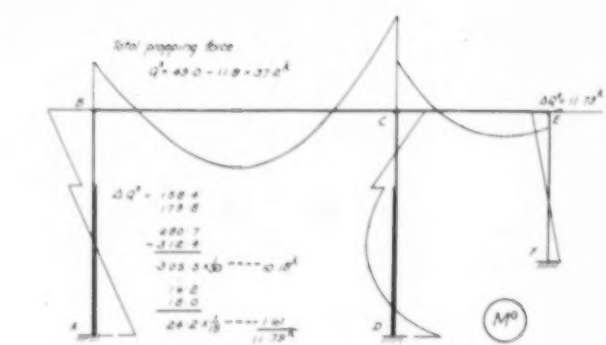
$S_{CE} = S_{EC} = 4\frac{6I_0}{20} = 1.2I_0 \quad 2S_C = 1.5$

$S_{EF} = S_{FE} = 4\frac{0.67I_0}{18} = 0.149I_0 \quad 2S_E = 0.583$

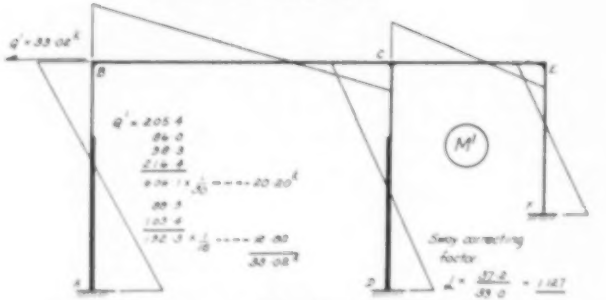
BA	BC	CB	CD	CE	EC	EF	FE
.147	.853	.636	.109	.255	.78	.25	
-9.0	-800.0	800.0	-809.7	-66.7	66.7		
118.3	690.1	845.0		-25.0	-50.0	-16.7	-8.3
	-268.6	-637.2	-92.0	-215.4	-107.7		
39.5	229.1	114.5		90.4	80.8	24.9	13.4
	-49.2	-98.5	-16.9	-39.5	-19.7		
7.4	41.8	20.9		7.4	14.9	4.9	2.4
	-3.0	-18.0	-3.1	-7.2	-3.6		
1.8	7.7	3.8		1.3	2.7	.9	.4
	-1.6	-3.2	-0.6	-1.3	-0.6		
.2	1.4	.7		.2	.4	.2	.1
	-0.3	-0.6	+0.1	-0.2			
.1	.2						
179.8	156.4	427.6	-921.4	-306.0	-16.2	16.2	8.0
BC							
3.80.7							
-81.6							
-15.0							
-2.8							
-0.5							
-0.1							
280.7							

MOMENTS UNDER PROPPED CONDITIONS

Fig. 6.



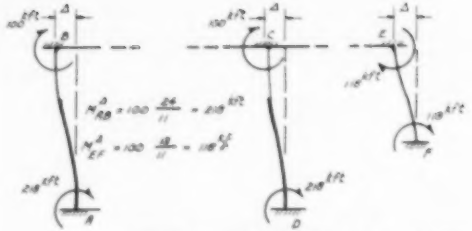
PROPPED CONDITIONS



MOMENTS DUE TO ARBITRARY DISPLACEMENT

Fig. 7.

(See page 384.)



FIXED END MOMENTS DUE TO ARBITRARY DISPLACEMENT

AB	BA	BC	CB	CD	DC	CE	EC	EF	FE
	147	853	426	109	285		76	25	
218·0	100·0			1000		44·2		18·0	118·0
-18·1	-14·7	-85·3	-42·6		44·2		-88·4	-29·4	-14·8
		-42	-8·4	-1·4	-3·4		-1·7		
5	4	3·0	1·8		·6		1·3	4	2
		-0·7	-1·5	-0·3	-0·6		-0·3		
	1	6					2	1	
205·4	86·0	-86·0	-50·7	99·3	-47·4		-88·9	88·9	103·4

2C

218·0	
-1·3	
-0·3	
216·4	

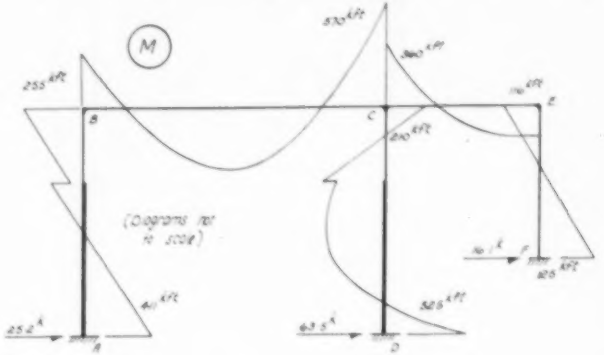
MOMENTS DUE TO ARBITRARY DISPLACEMENT

(M')

Fig. 8.

M = M° + μM'

	AB	BA	BC	CB	CD	DC	CE	EC	EF	FE
M°	173·8	158·4	-158·4	427·4	-381·9	280·7	-306·0	-16·2	16·2	8·0
μM'	231·5	34·3	-34·3	-57·1	110·2	243·3	-53·6	-100·2	100·2	110·5
M	411	255	-255	370	210	525	-360	116	-116	125



$H_A = \frac{255}{411} \times 50 = 22.2^k$

$H_B = \frac{525}{210} \times 50 = 105^k$

$H_E = \frac{116}{241} \times 50 = 24.1^k$

Check

$\Sigma H = 25.2^k + 63.5 + 16.4 = 104.8^k$

$H = 105.0^k$

FINAL MOMENTS

Fig. 9.

(See page 384.)

Concrete and Structural Form.

The following is an abstract of an address given by Professor Pier Luigi Nervi at a meeting in London last month arranged by the Cement and Concrete Association. The address was illustrated by lantern slides of structures designed by the speaker, who was also responsible for their construction as a partner and technical director of the firm that built them.

The fact that design and actual construction could be united in this way was due to the method of placing contracts, known as the " competition-tender ", that was already fairly widespread and was tending to be increasingly used in Italy. The method consisted in inviting a number of well-qualified firms to submit a tender including the design as well as a quotation. The design was based on an outline provided by the client which allowed ample freedom for the best architectural and structural solutions of the problem, and the client selected the design that seemed the most satisfactory from all points of view. A design that was good æsthetically and technically was nearly always sufficiently economical, and the client might accept a tender that was not the lowest if the qualities of the design outweighed a small difference in cost.

The advantages of such a system were obvious. Competition stimulated the designer-contractor to develop the most suitable design from the economical as well as from the technical points of view, and to study new and more efficient building methods for its erection. His knowledge of materials and his study of methods of construction would ensure a realistic approach to the design, but they might also suggest daring solutions that might have seemed impossible to the consultant. Moreover, the designer-contractor could carry out costly tests and experiments that would be practically impossible for the consultant.

The most important characteristics of the speaker's works were that they were the result of a constant endeavour to find the most efficient design from the technical and the economic point of view. All his designs were therefore the direct result of structural or constructional considerations. He was deeply convinced that the outward appearance of a good building could not, and must not, be anything but the visible expression of an efficient structural or constructional reality. In other words, form must be the necessary result, and not the initial basis, of structure.

The stadium (*Figs.* 1 and 2) at Florence was built in 1927. The only requirements specified by the client were that the stadium should hold 35,000 spectators, the dimensions of the covered stand, the length of the running track, the provision of a Marathon tower, and a few more details of a general nature. Essential items from the architectural and economical points of view were the design of the wide-span canopy over the stand, the open stands, the external staircases (*Fig.* 3) and Marathon tower. The design for the covered stand provided for the equilibrium of the whole structure without anchorage to the ground; these anchorages were always uneconomical because they required large quantities of material to counteract the forces transmitted through the structure from the anchorage to the ground. The variation in the cross sections of the main ribs was determined by the law governing the variation of the bending moments. Æsthetic considerations only inspired the slight curve of the canopy and the haunching of the main ribs. He found exact calculation of the staircases to be impossible, and therefore limited himself to calculating this complex statically-indeterminate system in terms of simple statically-determinate elements, and calculated them for the greatest stability even at the cost of high unit stresses, as he was confident that the plastic qualities of concrete would produce a fully monolithic structure. Events had fully justified his confidence, and acceptance tests and—more important—time and use had demonstrated the perfect stability of the structure.

In 1935 the speaker's firm built for the Italian Air Force hangars (*Fig.* 4) spanning 330 ft. by 135 ft. internally with door openings of 165 ft. span. The structure was designed as a geodetic frame acting together as a whole, as it was believed that this would be the most economical and require the least amount of steel. The calculations were extremely complicated, so a preliminary calculation was made followed by a study of the stresses by means

of experiments on a model. The model experiments were carried out at Milan Polytechnic, under the direction of Professor Danusso and Professor Oberti ; this was thought to be one of the first instances in which the results of model tests had been applied to a very large structure. The estimates provided by the preliminary calculations used in the construction of the model required hardly any alteration.

In 1940 the Italian Air Force invited tenders for the construction of another hangar (*Fig.* 5) of similar dimensions. At that time, the need for economy in materials and timber had become even more acute, and he decided to simplify and lighten the structure by designing the ribs as a lattice which would enable use to be made of prefabrication. The system of supports was also altered in order to simplify the static system and make it more symmetrical. In this case also model tests were made, and the greater structural simplicity and the study made of the previous hangar enabled a still better approximate calculation to be made, the results of which agreed exactly with those of the model tests. The pre-

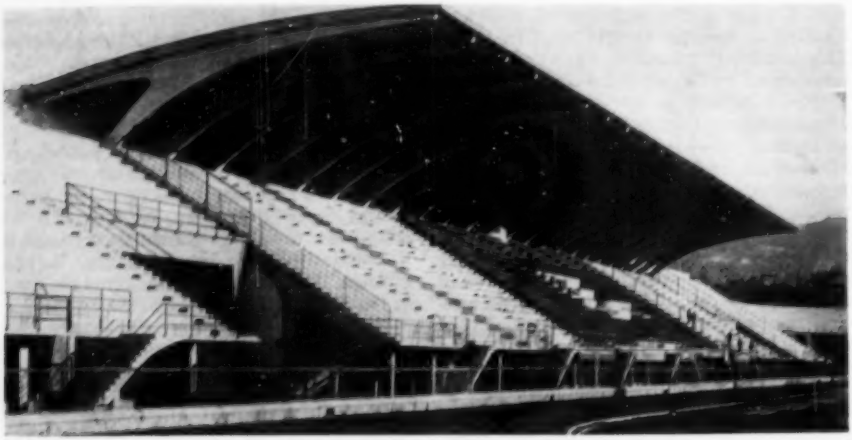


Fig. 1.—Stadium at Florence.

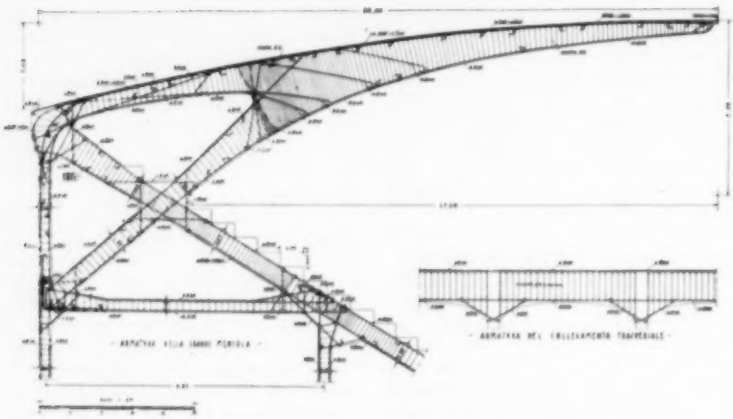


Fig. 2.—Stadium at Florence : Cross Sections of Stand.

casting of the units and their erection were simple. The method of assembly had been tested by his firm and at the Milan Polytechnic. The joints were made by welding the steel and placing high-strength concrete in situ in the space left at the junction of four units. The Germans demolished the supporting columns, but even

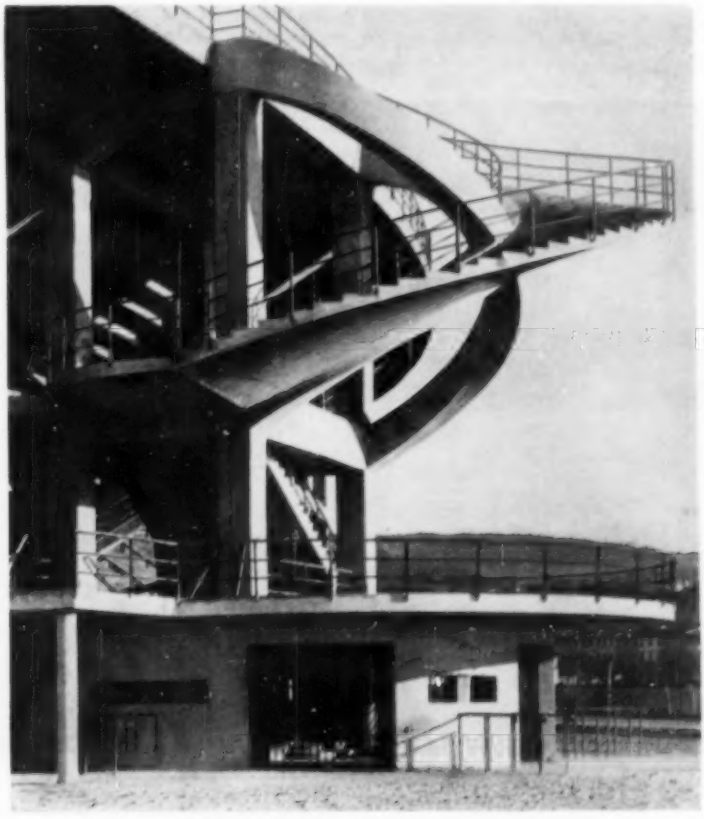


Fig. 3.—Stadium at Florence: External Staircase.

after the fall of the roof most of the joints were still intact.

Conditions after the war led him to work on a new type of construction called "ferro-cement", based on the principle of a very thin highly reinforced slab obtained by forcing a very good quality mortar, made with cement and sand, through several layers of steel mesh and bars of small diameter, joined together to form a section only a little thinner than the final slab. The mortar was placed by hand and by vibration, and the results were extremely promising because of the exceptional flexibility, strength, and freedom from cracking of the slabs so obtained, and even more because the mortar was supported by the mesh with the result that the shuttering could be simpler or dispensed with altogether. This method was devised mainly for the quick construction of small ships not exceeding 500 tons. In 1943, work was started on three motor-transport boats for the Italian Navy and one sailing ship with auxiliary motor. The war prevented the completion of this work, but in 1945 a yacht with a hull 1¼ in. thick was built that was still

in use and in perfect condition, and in 1948 the method was adopted to build a 40-ft. ketch with a hull ½ in. thick. These designs, and others for ships and buildings, gave the necessary experience to attempt, in 1948, the roof of the Exhibition Hall at Turin.

The Exhibition Hall (*Figs.* 6 and 7) at Turin was particularly interesting because of its dimensions (nearly 330 ft. span) and because of the very short time allowed for its erection, which was to start in September and be finished by the end of April. The solution was a structure in corrugated " ferro-cement ", which would have the necessary stability by virtue of the corrugations and would enable the roof units to be precast while the floors and supporting structure were being built. The corrugations were about 8 ft. span and the units about 13 ft. long, made of " ferro-cement " 1½ in. thick and made monolithic by reinforced concrete ribs cast in situ at the peaks and troughs of the corrugations. In this way " ferro-cement " units acted as junction units between the in-situ ribs. The units were closed at each end by stiffening diaphragms, and adjacent units joined together by mortar 1½ in. thick placed in situ. Because of the richness of the mortar (1350 lb. of high-strength cement to 1 cu. yd. of sand), the moulds were removed two or three days after casting. About 3230 sq. ft. of roof were erected each day.

Construction was done in three stages to get the fullest use from the movable shuttering. The corrugated roof was connected to the main supporting columns (which were at 24 ft. 7½ in. centres) by fan-shaped " ferro-cement " units springing from inclined reinforced concrete elements.

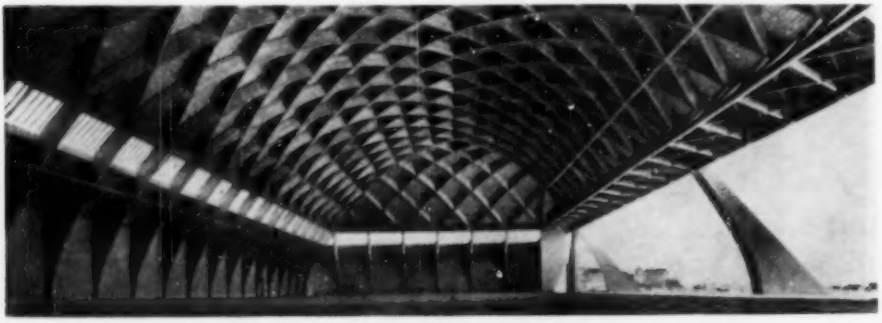


Fig. 4.—Aircraft Hangar at Orvieto.

Fig. 5.—Hangar at Orletello.

For the design of the 130-ft. diameter half-dome (*Fig.* 8) at the end of the main exhibition hall in Turin, a method based on precast units was used. The method consisted in filling the space to be covered with precast units measuring about 6 ft. 6 in. by 13 ft. The units were cast in concrete moulds. The edges of each unit

formed channels about 4 in. wide between the units, which were filled with in-situ reinforced concrete and formed ribs that completed the structural system. The units were made of " ferro-cement " and were ⅜ in. thick. During erection they were supported on scaffolding and required no centering.

A year later another hall, measuring 180 ft. by 540 ft., was built close to the main hall. The work was to be started in November and completed before the end of March. It was again necessary to use precasting, which could conveniently be carried out in the basement of the adjoining main hall. The second hall had a hipped vault, supported by four arches on a sloping plane with a slope nearly corresponding to the thrust of the vault.

For the construction of the vault the same method was used as for the half-dome in the main hall, covering the area with precast units in rows parallel to the angles of the roof and allowing for a strip of glazing around the edges to admit light; the units in this part of the roof consisted only of the channels forming the ribs. For the surrounding flat-roofed portion, which spans 33 ft., corrugated beams in " ferro-cement ", precast at the same time as the vault units, were used; these beams were placed side by side and covered with a lightweight topping. The beams were ⅜ in. thick at the top, increasing to 1½ in. at the soffit to provide room for the reinforcement. They were cast in concrete moulds. The visible underside of the beam, which was in contact with the mould during casting, had a perfection of surface that could not be obtained by any of the usual finishing processes.

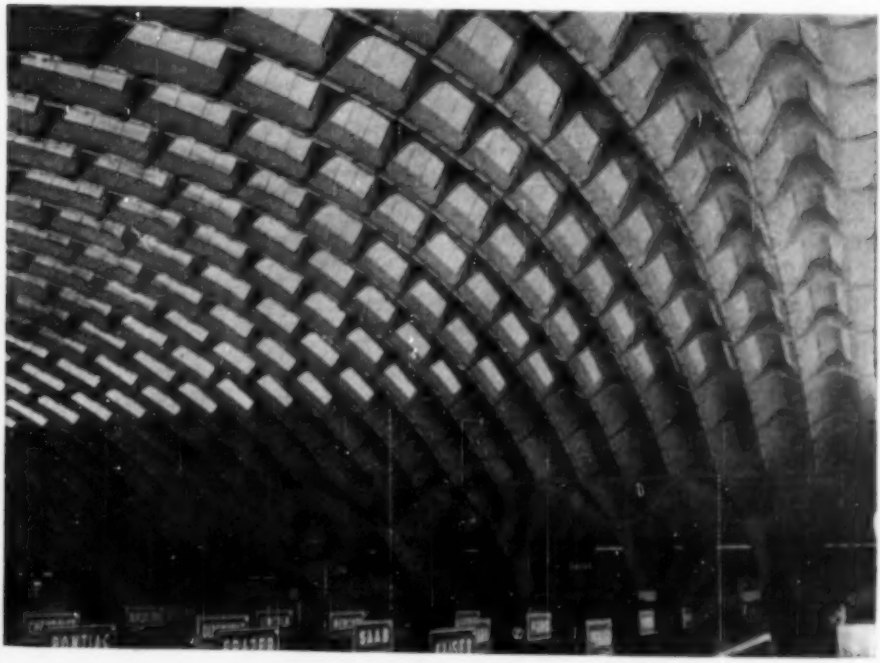


Fig. 6.—Exhibition Hall, Turin.

An interesting application of precasting for the construction of vaults and domes was the elliptical roof of the hall in the new baths at Chianciano. The elliptical plan made it necessary to use shuttering for half the roof, but here again the method proved satisfactory as regards the quality of the work and the saving in time compared with in-situ work.

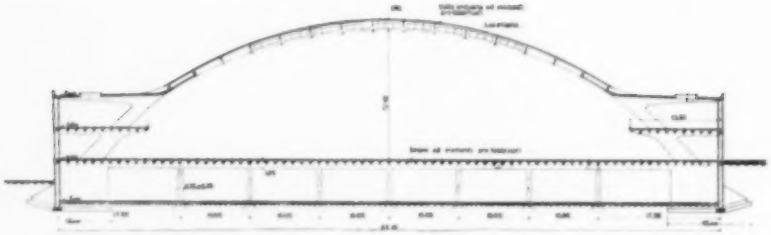


Fig. 7.—Exhibition Hall, Turin : Cross Section.

The development of reinforced concrete from the engineering and architectural points of view was closely linked to a liberation from the restrictions imposed by timber shuttering, which obliged the designer to conform to the pattern of timber construction and was in direct opposition to the plasticity of form that was the most important structural and architectural characteristic of reinforced concrete. Precasting, the use of " ferro-cement ", and methods of roof construction with travelling " ferro-cement " shuttering, might be a step in this direction.

After the first unfortunate attempts to adapt the new material to the structural forms of masonry or timber, design in reinforced concrete turned quickly towards new structural forms, which were found to have an inherent beauty of their own. The most characteristic architectural forms of reinforced concrete in the last few years had been the cause and the consequence of a widespread orientation towards a genuinely constructional architecture. Perhaps we did not realise how important it was to have freed architecture from a complex of rules and traditions which, however much they corresponded to structural reality at the time of their inception, had gradually lost any significance and became a sterile formalism. At present architecture was full of promise but the danger of slipping into structural formalism should never be overlooked : alarming symptoms of it could already be seen in the architectural work illustrated

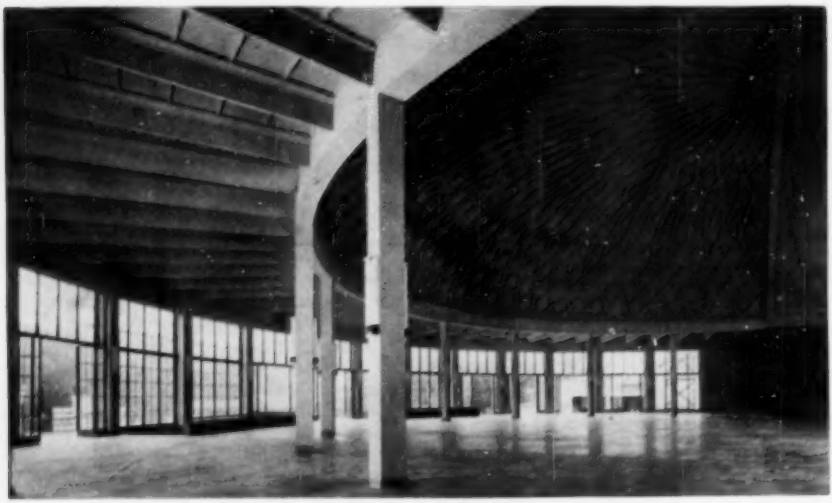
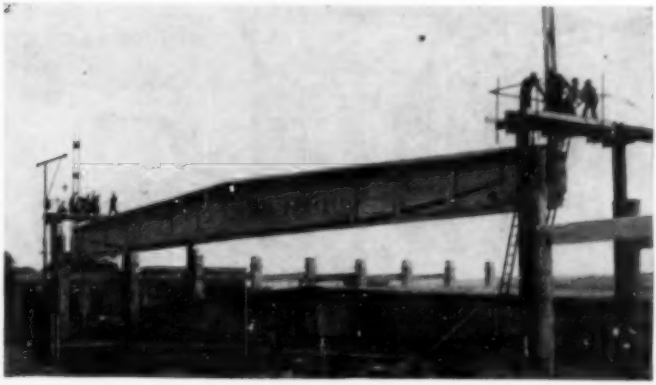


Fig. 8.—Half Dome at Turin Exhibition.

in the periodicals of all countries. This derived from the fact that too often, through a lack of understanding of its structural and constructional essence, a structure was considered solely on the basis of its external appearance—which people tried to adapt to a variety of different problems as regarded both dimensions and strength. The result was always unfortunate. The prime condition of architectural expression in a structure was the correctness and the inevitability of its structural design. Constructional complications, or designs that required structural acrobatics, were always a sign of a false structural conception—even to the untrained eye of the non-technical observer.

To deal worthily with the ever more ambitious architectural projects of the future the architect must possess æsthetic sensibility, profound understanding of structural needs, and a precise knowledge of the methods, possibilities, and limitations of constructional methods. If it were not possible to unite in the young constructor artistic sensibility, technical wisdom, and knowledge of building methods, the hopes of the new architecture would be to a great extent frustrated. Until the training of the complete architect could be achieved, good results could be obtained through the sincere collaboration of different people, each contributing the specific knowledge lacked by the others. Architect, engineer, and constructor could, in this way, bring about the union of art and science that was necessary for the solution of any constructional problem. The contribution of technical-constructional knowledge was effective only if it was brought into collaboration with the architect from the inception of the scheme.

Prestressed Roof Beams of 123 ft. Span.



In the article under the above title on pages 370 and 371 of the October number of this journal it should have been stated that the architect for the factory at Pennyburn, Northern Ireland, is Mr. A. T. Marshall, A.R.I.B.A., of Londonderry and the consulting engineer Mr. Donovan Lee, M.I.C.E., of London. Messrs. John Eakin & Co., Ltd., were the general contractors, and Concrete Piling, Ltd. (who devised the method of lifting the beams shown in the above illustration), the contractors for the whole of the concrete work.

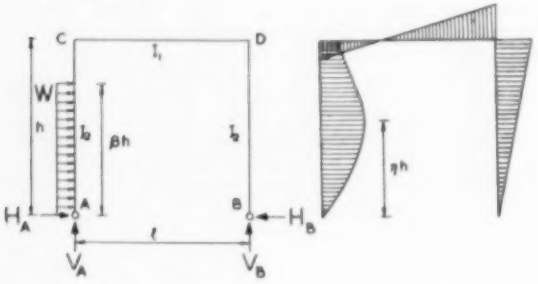
The Analysis of Frames by the Nomographic Method.—2.*

By J. RYGOL, B.Sc.(Eng.).

HORIZONTAL LOADING ON COLUMN AC.

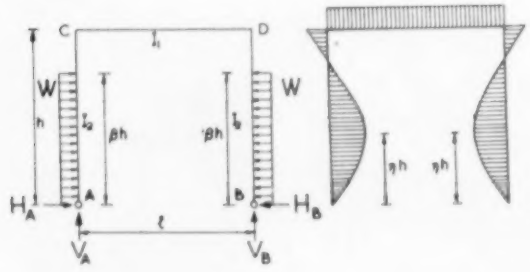
Standard Loading 5.—Uniformly-distributed load. Total load $W = w\beta h$. c_5 from Nomogram No. 5.

Simple Loading.—



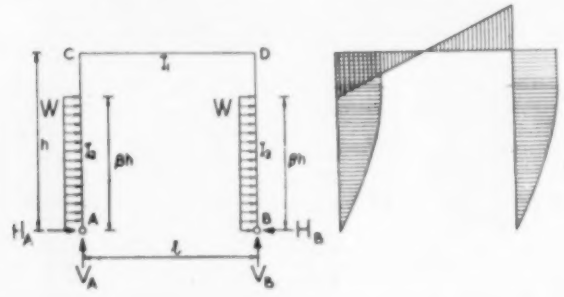
$$H_B = c_5 W.$$
$$H_A = -(1 - c_5)W.$$
$$M_C = \left(\frac{\beta}{2} - c_5\right)Wh.$$
$$M_D = -c_5 Wh.$$
$$M_\eta = \left[\frac{\beta}{2}(1 - c_5)^2\right]Wh;$$
$$\eta = \beta(1 - c_5).$$
$$V_B = -V_A = \frac{\beta}{2r}W.$$

Symmetrical Loading.—



$$H_A = H_B = -(1 - 2c_5)W.$$
$$M_C = M_D = \left(\frac{\beta}{2} - 2c_5\right)Wh.$$
$$M_\eta = \left[\frac{\beta}{2}(1 - 2c_5)^2\right]Wh;$$
$$\eta = \beta(1 - 2c_5).$$
$$V_A = V_B = 0.$$

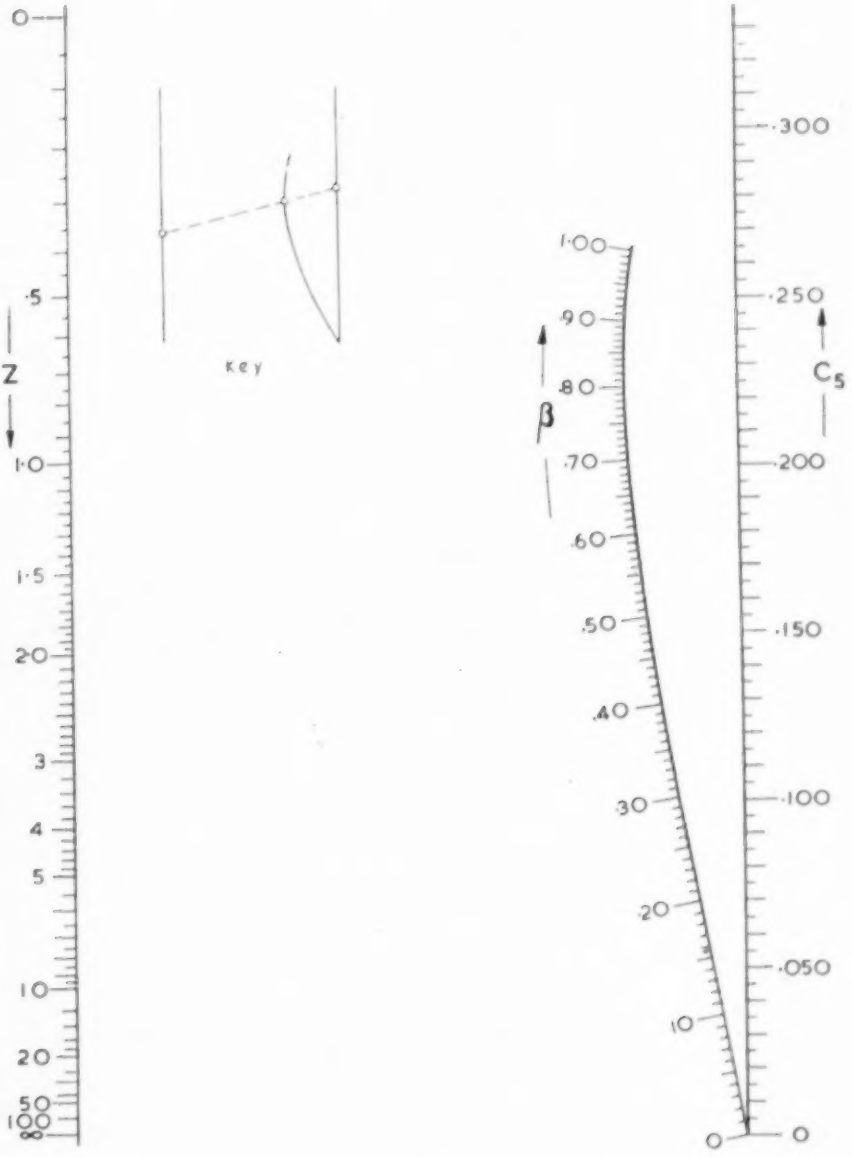
Antimetrical Loading.—



$$H_A = -H_B = -W.$$
$$M_C = -M_D = \frac{\beta}{2}Wh.$$
$$M_{\beta(AC)} = -M_{\beta(BD)} = \frac{\beta}{2}Wh.$$
$$V_A = -V_B = -\frac{\beta}{r}W.$$

* Concluded from October number.

Nomogram No. 5.

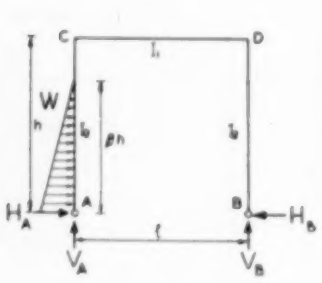


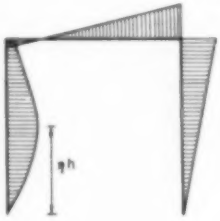
STANDARD LOADING No. 5.—BOTH COLUMNS HINGED AT BASE.
Coefficient c_4 for Horizontal Thrust.

Horizontal Loading on Column AC.

Standard Loading 6.—Triangular load. Total load $W = w\frac{\beta}{2}h$. c_6 from Nomogram No. 6.

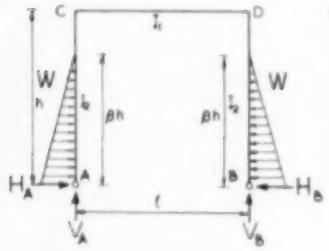
Simple Loading.—

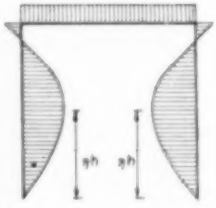




$$H_B = c_6 W.$$
$$H_A = -(1 - c_6)W.$$
$$M_C = \left(\frac{\beta}{3} - c_6\right)Wh.$$
$$M_D = -c_6 Wh.$$
$$M_\eta = \left[\frac{\beta}{3}(1 - \sqrt{c_6})^2 (1 + 2\sqrt{c_6})\right]Wh$$
$$\eta = \beta(1 - \sqrt{c_6}).$$
$$V_B = -V_A = \frac{\beta}{3\ell}W.$$

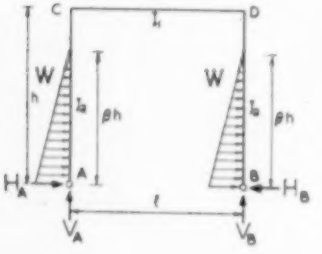
Symmetrical Loading.—

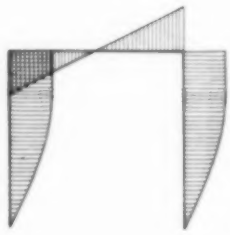




$$H_A = H_B = -(1 - 2c_6)W.$$
$$M_C = M_D = \left(\frac{\beta}{3} - 2c_6\right)Wh.$$
$$M_\eta = \left[\frac{\beta}{3}(1 - \sqrt{2c_6})^2 (1 + 2\sqrt{2c_6})\right]Wh$$
$$\eta = \beta(1 - \sqrt{2c_6}).$$
$$V_A = V_B = 0.$$

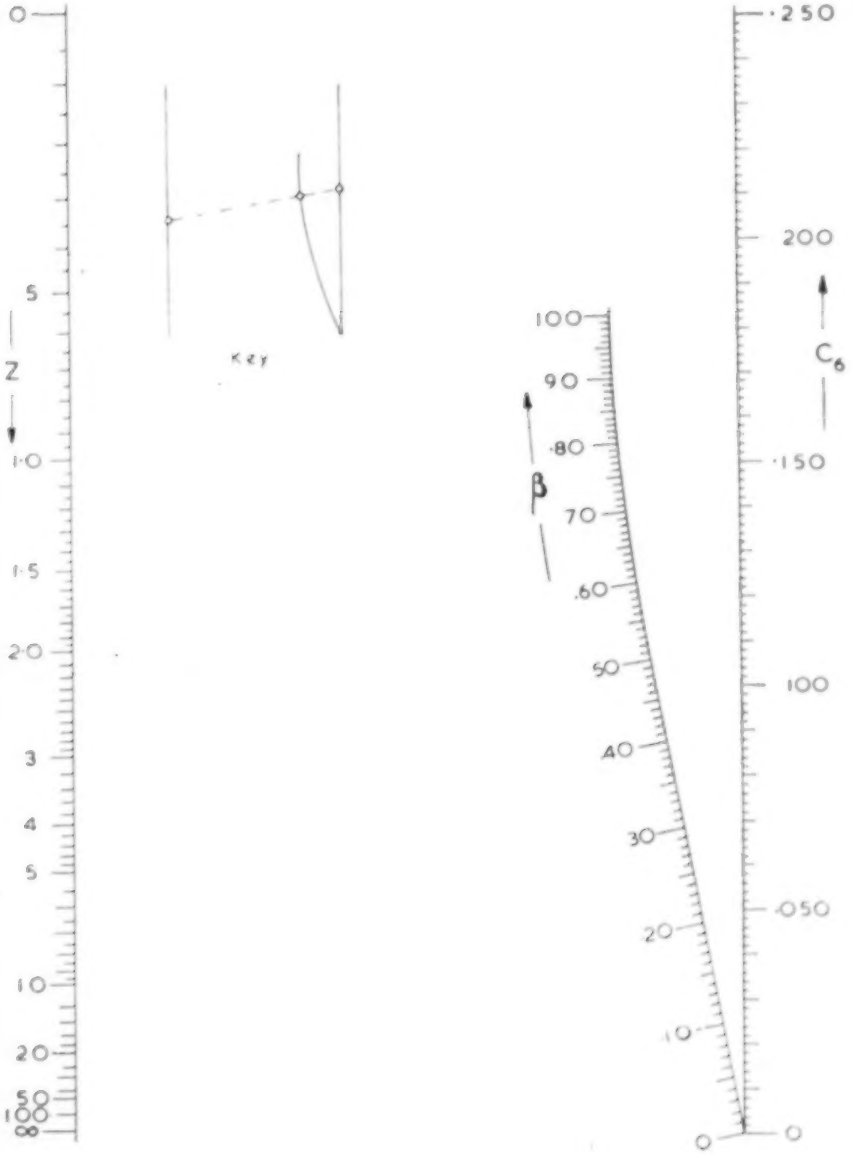
Antimetrical Loading.—





$$H_A = -H_B = -W.$$
$$M_C = -M_D = \frac{\beta}{3}Wh.$$
$$M_{\beta(AC)} = -M_{\beta(BD)} = \frac{\beta}{3}Wh.$$
$$V_A = -V_B = -\frac{2\beta}{3\ell}W.$$

Nomogram No. 6.

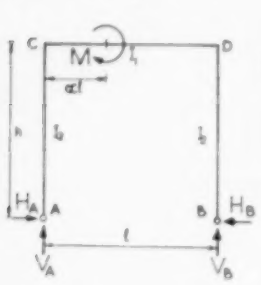


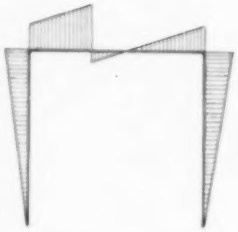
STANDARD LOADING No. 6.—BOTH COLUMNS HINGED AT BASE.
Coefficient c_6 for Horizontal Thrust.

EXTERNAL MOMENTS.

Standard Loading 7.—Moment M acting on beam CD. c_7 from Nomogram No. 7.

Simple Loading.—





$H_A = H_B = c_7 \frac{M}{h}$.

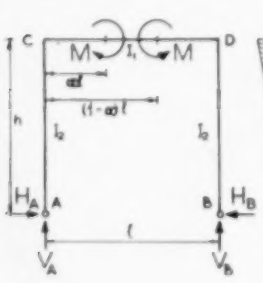
$M_C = M_D = -c_7 M$.

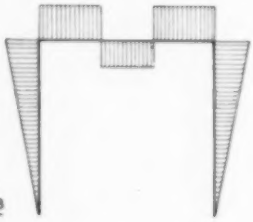
Left $M_\alpha = -(\alpha + c_7)M$.

Right $M_\alpha = (1 - \alpha - c_7)M$.

$V_A = -V_B = -\frac{M}{l}$.

Symmetrical Loading.—





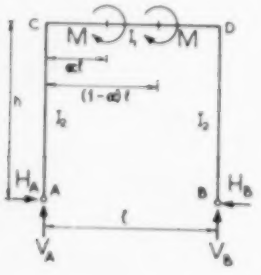
$H_A = H_B = 2c_7 \frac{M}{h}$.

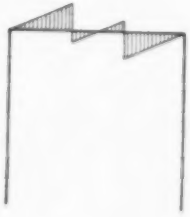
$M_C = M_D = -2c_7 M$.

Right M_α
= Left $M_{1-\alpha} = (1 - 2c_7)M$.

$V_A = V_B = 0$.

Antimetrical Loading.—





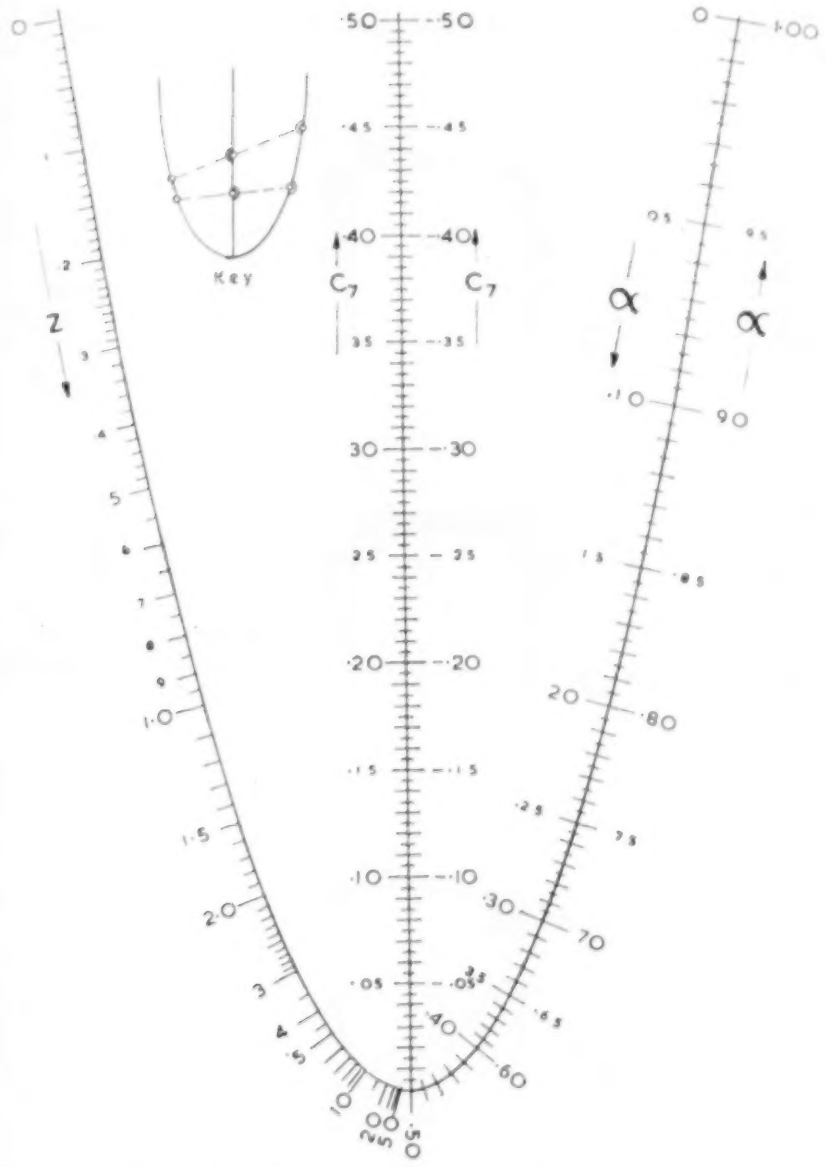
$H_A = H_B = 0$.

Left $M_\alpha = -2\alpha M$.

Right $M_\alpha = (1 - 2\alpha)M$.

$V_A = -V_B = -2\frac{M}{l}$.

Nomogram No. 7.

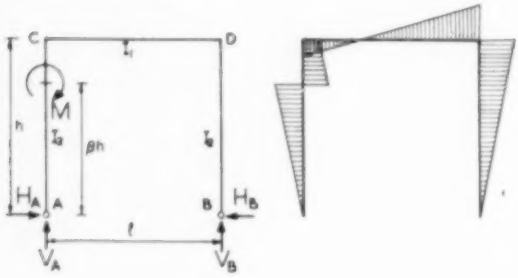


STANDARD LOADING No. 7.—BOTH COLUMNS HINGED AT BASE.
Coefficient c_7 for Horizontal Thrust.

External Moments.

Standard Loading 8.—Moment M acting on column AC. c_s from Nomogram No. 8.

Simple Loading.—



$$H_A = H_B = c_s \frac{M}{h}.$$

$$M_C = (1 - c_s)M.$$

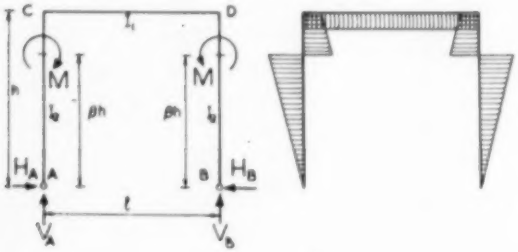
$$M_D = -c_s M.$$

Lower $M_\beta = -\beta c_s M.$

Upper $M_\beta = (1 - \beta c_s)M.$

$$V_A = -V_B = -\frac{M}{l}.$$

Symmetrical Loading.—



$$H_A = H_B = 2c_s \frac{M}{h}.$$

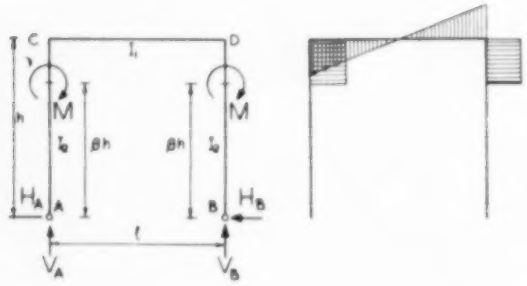
$$M_C = M_D = (1 - 2c_s)M.$$

Lower $M_\beta = -2\beta c_s M.$

Upper $M_\beta = (1 - 2\beta c_s)M.$

$$V_A = V_B = 0.$$

Antimetrical Loading.—



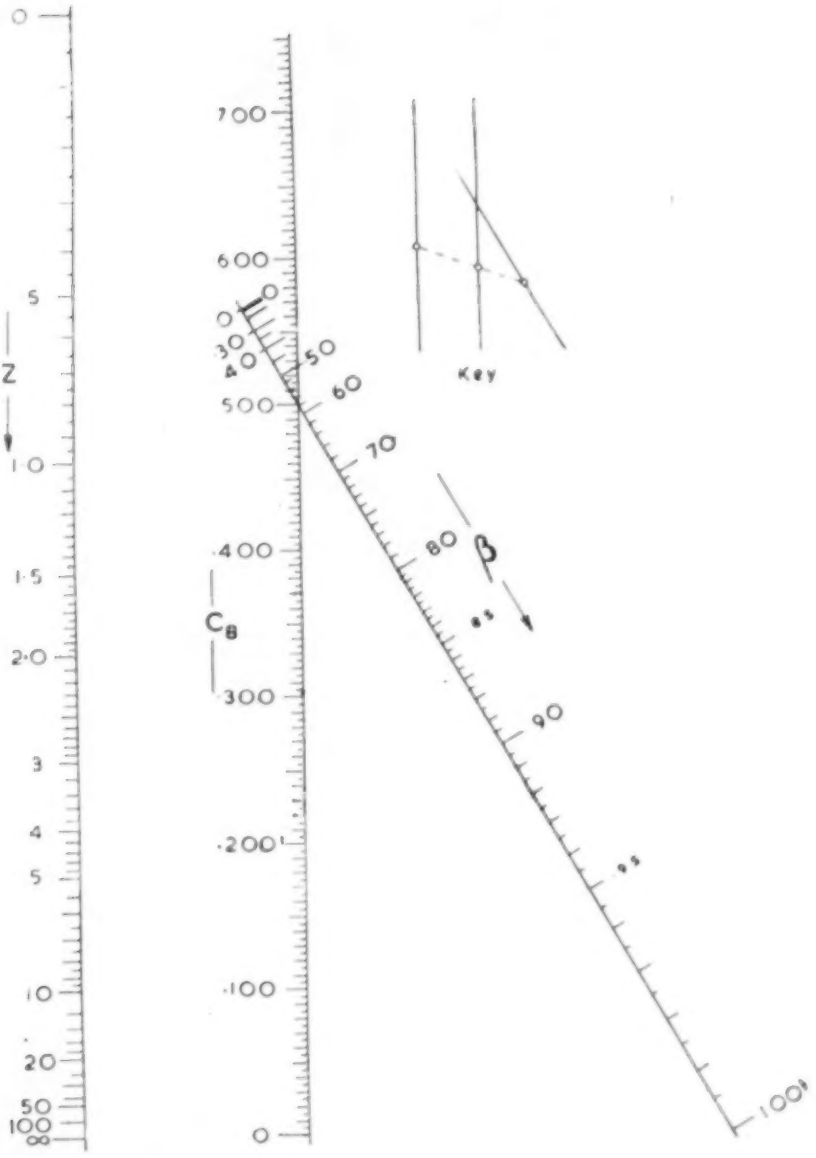
$$H_A = H_B = 0.$$

$$M_C = -M_D = M.$$

$$M_{\beta(AC)} = -M_{\beta(BD)} = M.$$

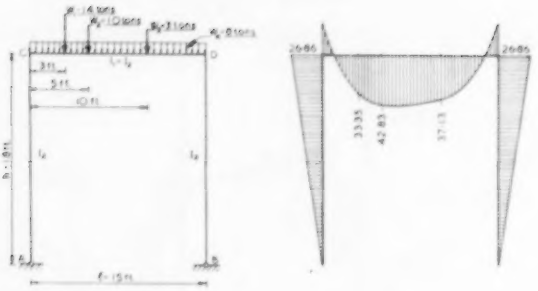
$$V_A = -V_B = -2\frac{M}{l}.$$

Nomogram No. 8.



STANDARD LOADING No. 8.—BOTH COLUMNS HINGED AT BASE.
Coefficient c_B for Horizontal Thrust.

Examples.



(*a*) (*b*)

[Bending moments in foot-tons.]

Fig. 5.—Bending-Moment Diagrams.

EXAMPLE 1.—Analyse the frame shown in *Fig. 5a*. $l = 15$ ft. $h = 18$ ft. $I_1 = I_2$. $z = \frac{I_1 h}{I_2 l} = \frac{18}{15} = 1{\cdot}20$. $r = \frac{l}{h} = \frac{15}{18} = 0{\cdot}833$.

From Nomogram 1 C_0	Load No.	Load W tons	G	From Graph 1: k	kW tons
$r = 0{\cdot}833$	1	14	0·200	0·640	8·960
$z = 1{\cdot}200$	2	10	0·333	0·888	8·880
$c_0 = 0{\cdot}05775$	3	3	0·667	0·888	2·664
	4	8	1·000	0·667	5·336
		$\Sigma W = 35$			$\Sigma kW = 25{\cdot}840$

The horizontal thrust $H = c_0 \Sigma kW = 0{\cdot}05775 \times 25{\cdot}840 = 1{\cdot}492$ tons.

$M_A = M_B = -18 \times 1{\cdot}492 = -26{\cdot}856$ ft.-tons.

$V_B = 14 \times 0{\cdot}200 + 10 \times 0{\cdot}333 + 3 \times 0{\cdot}667 + 8 \times 0{\cdot}500 = 14{\cdot}13$ tons.

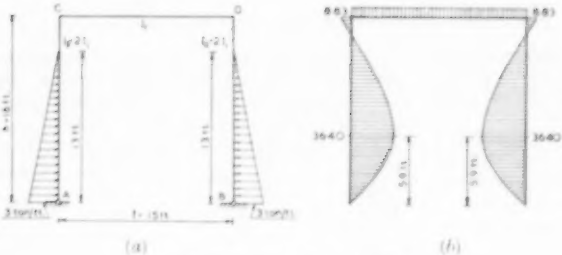
$V_A = 35 - 14{\cdot}13 = 20{\cdot}87$ tons.

The bending moments at W_1, W_2, and W_3 are:

$$M_1 = -26{\cdot}856 + 20{\cdot}87 \times 3 - \frac{8 \times 3^2}{15 \times 2} = 33{\cdot}354 \text{ ft.-tons.}$$

$$M_2 = -26{\cdot}856 + 20{\cdot}87 \times 5 - \frac{8 \times 5^2}{15 \times 2} - 14 \times 2 = 42{\cdot}827 \text{ ft.-tons.}$$

$$M_3 = -26{\cdot}856 + 14{\cdot}13 \times 5 - \frac{8 \times 5^2}{15 \times 2} = 37{\cdot}127 \text{ ft.-tons.}$$



(*a*) (*b*)

[Bending moments in foot-tons.]

Fig. 6.—Bending-Moment Diagrams.

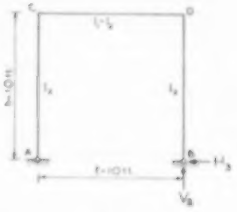


Fig. 7.

EXAMPLE 2.—Analyse the frame shown in *Fig. 6a*. $l = 15$ ft. $h = 16$ ft. $I_2 = 2I_1$. $z = \dfrac{I_1 h}{I_2 l} = \dfrac{16}{2 \times 15} = 0{\cdot}533$. $r = \dfrac{l}{h} = \dfrac{15}{16} = 0{\cdot}937$. $\beta = \dfrac{13}{16} = 0{\cdot}812$.

Total load $W = 13 \times \frac{3}{2} = 19{\cdot}5$ tons. From Nomogram No. 6, $c_4 = 0{\cdot}1495$.

Using the formulæ for Standard Loading No. 6, Symmetrical Loading,

$$H_A = H_B = -(1 - 0{\cdot}299)19{\cdot}5 = -13{\cdot}67 \text{ tons.}$$

$$M_C = M_D = (0{\cdot}2707 - 0{\cdot}2990)19{\cdot}5 \times 16 = -8{\cdot}83 \text{ ft.-tons.}$$

$$\xi = 0{\cdot}812(1 - \sqrt{0{\cdot}2990}) = 0{\cdot}368.$$

$$M_\xi = 0{\cdot}2707(1 - \sqrt{0{\cdot}2990})^2(1 + \sqrt{2{\cdot}2990})19{\cdot}5 \times 16 = 36{\cdot}4 \text{ ft.-tons.}$$

$$V_A = V_B = 0.$$

EXAMPLE 3.—Construct influence lines for horizontal thrust H_B and vertical force V_B in a frame with a span of 10 ft., a height of 10 ft., and equal moments of inertia of all members (*Fig. 7*). $l = 10$ ft. $h = 10$ ft. $I_1 = I_2$.

$$z = \frac{I_1 h}{I_2 l} = \frac{10}{10} = 1. \quad r = \frac{l}{h} = \frac{10}{10} = 1.$$

The ordinates of the influence lines for H_B and V_B are given by:

Unit load on column AC: $H_B = c_4$. $V_B = \dfrac{\beta}{r} = \beta$.

Unit load on beam CD: $H_B = c_6 k_1$. $V_B = \alpha$.

Unit load on column BD: $H_B = -(1 - c_4)$. $V_B = -\dfrac{\beta}{r} = -\beta$.

These equations show that the influence line for V_B consists of straight lines with maximum ordinates at α and β equal to unity. From Nomogram No. 1, $c_6 = 0{\cdot}075$.

Photographs of Roads, Bridges, and Garages.

AN exhibition of photographs of roads, bridges, and garages in various parts of the world will be held at the Institution of Civil Engineers, London, from November 8 to 18, from 10 a.m. to 6 p.m. The exhibition is organised by the Institution of Highway Engineers, the Pavings Development Group (Concrete and Soil-Cement), and the Joint Committee on Structural Concrete (representing the Prestressed Concrete Development Group, the Cement and Concrete Association, and the Reinforced Concrete Association).

Book Reviews.

"First Congress of the Fédération Internationale de la Précontrainte." 254 pages. [Published by the Cement and Concrete Association. Obtainable from Concrete Publications, Ltd. Price 50s.; in Canada and the U.S.A. $10.50.]

THIS is a complete report of the proceedings of the First Congress of the Fédération Internationale de la Précontrainte held in London in 1953. Summaries of the papers presented are printed in the English, French, and German languages, and the discussions are printed in English only. The subjects dealt with, and the names of the authors and of those who took part in the discussions, are as follows:

"The Influence of Abnormal Temperatures on Prestressed Concrete Construction", by A. W. Hill, U. Bjuggren, S. H. Clark, R. V. Watson, and P. B. Morice.

"The Design of Statically-determinate Beams and Slabs in Prestressed Concrete, based on Ultimate Load", by G. Magnel, P. W. Abeles, G. Dardanelli, F. Levi, A. Paez, H. E. Lewis, A. Goldstein, P. B. Morice, A. Paduart, A. Lazard, A. Teixeira-Rego, D. H. Lee, U. Smet, A. L. L. Baker, C. Riviere, and R. H. Evans.

"Statically-indeterminate Structures in the Elastic and Plastic States", by Y. Guyon, G. Magnel, G. A. Steinmann, F. Levi, A. Amirikian, A. M. Haas, P. W. Abeles, H. E. Lewis, E. Giangreco, T. Brondum-Nielsen, R. S. Jenkins, A. Lazard, W. A. Evans, E. Shepley, and E. Hognestad.

"An Electric Model of Beams and Plates." By E. T. Rudso. [Copenhagen: Danish National Institute of Building Research. Kr. 1.]

AN account of the use of electrical models used to find the stresses in beams, and a discussion of the analogy existing between a simply-supported horizontal beam loaded by vertical forces and an electrical conductor "loaded" by electrical currents.

"Il Cemento Armato Precompresso." By Giuseppe Rinaldi. (Genoa: Edizioni Vitali e Ghianda. 1954. Price 2000 lire.)

THIS well-illustrated book, written in the Italian language, consists of four parts, namely, a brief review of the better-known methods of prestressing; summaries of the codes of practice or proposed codes of practice relating to prestressed concrete prepared in several European countries; typical calculations and drawings for two road-bridges, one of 22-metres and one of 46-metres span; and finally the details of a two-span road bridge together with the results of tests carried out on a full-size beam for this bridge. Most of the examples are of structures with post-tensioned cables, particular attention being given to applications of the method devised by the author.

"Forty Designs for Low-Cost Houses." (Bombay: The Concrete Association of India. Price Rs. 1/8.)

IN this brochure are given the winning designs in a competition sponsored by the Concrete Association of India for designs for houses of one or more stories and blocks of flats for construction in concrete. The designs range from bungalows of two rooms only to large blocks of residential flats. With each design perspective drawings and plans are given. The competition was in two parts, one for residences in wet districts and the other for residences in hot and dry districts. Generally it is recommended that precast concrete hollow blocks be used for both climates.

"Der Dammbau: Grundlagen und Geotechnik der Stau-und Verkehrsdämme." New edition. By Karl Keil. (Berlin: Springer-Verlag. Price 69 D.M.)

THIS edition has been much enlarged and improved, and presents an exhaustive study of earthen dams and ancillary problems, with examples. A long chapter deals with the use of machinery in earthworks.

"Rohrhydraulik: Ein Handbuch zur praktischen Strömungsberechnung." 2nd edition. By H. Richter. (Berlin: Springer-Verlag. 1954. Price 34.50 D.M.)

THIS book, printed in the German language, is a comprehensive work on the flow of liquids and gases through pipes. Based on theoretical and experimental investigations, it will be useful to engineers specialising in the subject. Examples of calculations are included.

"Report of the Advisory Committee on Sand and Gravel." Parts 14 and 15. East Lincolnshire and East Yorkshire. (H.M. Stationery Office. Price 6s. 6d.)

"Über die Knickung und Tragfähigkeit eines Exzentrisch Gedrückten Pfeilers ohne Zugfestigkeit." By Kyösti Angervo. (Helsinki: Valtion Teknillinen Tutkimuslaitos. No price stated.)—Deals with the bearing capacity and buckling of eccentrically-loaded columns without tensile strength, and is applicable to unreinforced concrete columns only.

Precast Concrete in an Office Building.

An office building with an elevation to Victoria Street, London, of 202 ft. 6 in. and a width of 48 ft., now nearing completion, is notable for the extensive use of precast members. There are eight floors above street level and two below ground. Part of the front of the building is set back at the sixth floor to provide a balcony about 4 ft. wide, and there is a further set-back at the eighth floor. A cantilevered portico at first-floor level will extend over the main entrance. The building permits the repetition of units of standard size, the design of which was made in collaboration with the contractors in order to take advantage of the facilities

Fig. 1.—May—Work in Progress on Second Floor.

Fig. 2.—August—Work in Progress on Eighth Floor.

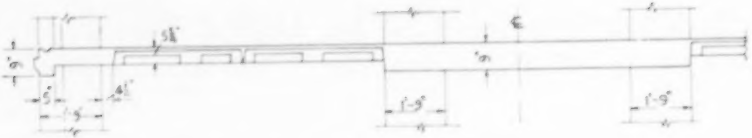


Fig. 3.—Typical Part Cross Section.

Fig. 4.—Precast Beams and Slabs.

at the contractors' precasting works and to permit rapid construction. A rate of construction of a floor in nine days was achieved (*Figs.* 1 and 2).

The foundations required the excavation of about 15,000 cu. yd. of sand and alluvial soil and the underpinning of two adjacent buildings. A considerable quantity of water was met and about 30,000,000 gallons were pumped out. At lower depths the water contained considerable quantities of sand, which was raised by the pump and collected in settling tanks before the water entered the drains.

The front row of columns is built on a plain concrete footing 9 ft. wide by 15 ft. deep. The structure is built on a module of 13 ft. 8 in. with four rows of columns longitudinally. The columns are generally 1 ft. 9 in. by 1 ft. in cross section and are spaced at 13 ft. 8 in. centres longitudinally and at 19 ft. 7½ in., 7 ft. 1 in., and 18 ft. 10½ in. centres transversely. The two intermediate rows of columns are 5 ft. 4 in. apart and joined at each floor by a reinforced concrete slab 9 in. thick, cast in place, which provides lateral stability to the building.

The columns and edge-beams (*Fig.* 3) are cast in place. The precast main beams, 1 ft. wide by 1 ft. 1 in. deep by 18 ft. 2½ in. or 17 ft. 5½ in. long, span between the columns, on which they have a bearing of 1½ in. Precast floor slabs span between these beams (*Figs.* 4 and 5); a typical slab is 12 ft. 11½ in. long by 4 ft. 6 in. wide. The central longitudinal rib of each slab is 7 in. wide and the edge ribs 3½ in. wide. The four transverse ribs are 3 in. wide. The ribs are 4¾ in. deep and the panels between them 1½ in. thick. The ribs on the periphery are battered ½ in. to provide a gap of 1 in. at the top. A concrete topping 1 in. thick, reinforced with steel mesh, is placed on top of the precast slabs, and on this the service pipes and conduits are arranged and covered by a further topping 3½ in. thick.

The external walls comprise precast units between columns cast in place. A

Fig. 5.—Underside of Precast Floor Slabs.

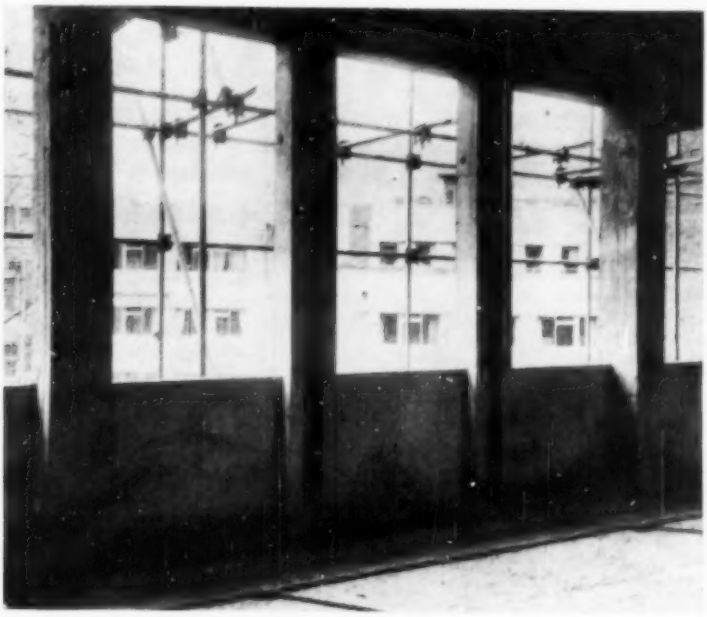


Fig. 6.—Precast Wall Unit.

typical wall unit is shown in *Fig.* 6 and comprises three panels up to window-sill level and two mullions the full height of the story. The mullions are 9 in. by 1 ft. in cross section and are of channel section to accommodate services. The units are temporarily supported in position, and reinforcement bars from the ends of the panels extend into the columns, which are then cast in wooden shutters.

A tower crane on a track along the rear of the building was used for hoisting all the precast members, materials, and other parts of the building; the heaviest units were precast staircases weighing 3½ tons. The precast beams weighed about 1¼ tons, the wall units 1¾ tons, and the floors slabs 15 cwt.

The front of the building is faced with Portland stone 3½ in. thick and the walls at the rear with bricks.

The building is being erected for Monsanto Chemicals, Ltd. The architects are Sir John Burnet, Tait & Partners, the engineer is Mr. Alfred Beer, A.C.G.I., A.M.I.C.E., M.I.Struct.E., and the contractors Messrs. Holland & Hannen and Cubitts, Ltd.

New Refractory Cement.

A WHITE calcium aluminate hydraulic cement with an alumina content of 70 to 75 per cent. and with total impurities less than 1 per cent., for use in refractory concrete, is now supplied by the Lafarge Aluminous Cement Co., Ltd. Refractory concretes incorporating this cement and a refractory aggregate have the setting-time and rapid hardening properties usually associated with high-alumina cement, but they also have a greatly enhanced refractoriness. Concretes made with this cement and corundum aggregate can be put into service within 24 hours of casting at temperatures up to 1800 deg. C.; such concretes do not shrink, and have high resistance to thermal shock. This cement may also be used with other refractory aggregates such as crushed firebrick, sillimanite, chrome, and chrome-magnesite.

Precast "Shell" Roofs.

A DEVELOPMENT of shell roof construction is described by Illia Doganoff of Bulgaria in a recent number of "Die Bautechnik", from which the following is abstracted.

Because "shell" roofs with positive Gaussian curvature have a high resistance to buckling and are practically free of internal bending stresses, they are exceptionally useful for rectangular areas but have been little used on account of the complicated and expensive shuttering required. The following describes a method used by the writer.

Construction.

Each section of the roof consists of a doubly-curved reinforced concrete shell monolithically connected to four reinforced concrete arches. This shell consists of separate precast elements, the two end elements having ribs along three sides and intermediate elements having ribs on two sides (*Fig.* 1). There are no ribs at the butt joints between the elements. The longitudinal arches consist of the ribs of the shell elements and precast reinforced concrete arches with a grouted connection between (*Fig.* 2). The transverse arches are formed solely by the ribs of the end shell-elements. The horizontal thrust of these arches is usually counteracted by tie-rods, but for small spans these are not necessary. For the more usual spans of 18 ft. to 36 ft. in one direction and 36 ft. to 90 ft. in the other, a shell about 1½ in. thick is sufficient, with possible thickening at the corners and along the edges.

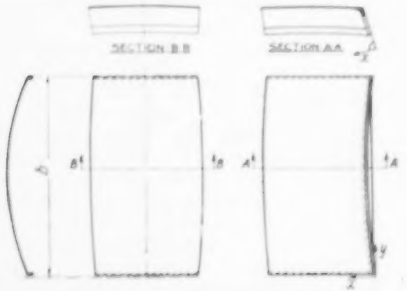


Fig. 1.—Doubly-curved Precast Shell Elements.

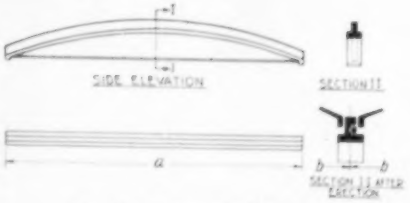


Fig. 2.—Longitudinal Arch.

Casting and Erection.

The shell-elements are cast in concrete moulds. Light steel frames are used to stiffen the edges of the elements during stripping of the moulds, transporting, and erection. These frames are shaped to the curvature of the edges of the elements and are rigidly connected to them by means of bolts passing through ferrules cast into the edges of the elements. The longitudinal arches are similarly prevented from tilting and buckling during erection. After the longitudinal arches are erected, the shells are erected on them and transmit their weight, by means of the temporary stiffening frames, to the longitudinal arches and so prestress the arches and the tie-rods. If necessary this prestress can be increased by temporary additional loading. All the parts of the roof are then joined by means of cast-in steel lugs, which are grouted. The removal of the frames results in a rearrangement of stresses in the shells and arches. While the frames are in position each shell-element and frame acts as a separate shell; the longitudinal arches are acted upon by vertical concentrated loads and the hardened grout is unstressed. On removal of the frames the whole roof acts as a monolithic structure.

Considerable savings in material are claimed to be possible by the use of doubly-curved shells, and by using precast elements the following additional advantages are claimed: (1) Absence of shuttering and scaffolding, greater strength of the concrete, increased spacing of expansion joints, and reduction of construction time. (2) Absence of deflection when centering is removed. (3) Saving of steel and concrete. For shells and arches for a roof, without top

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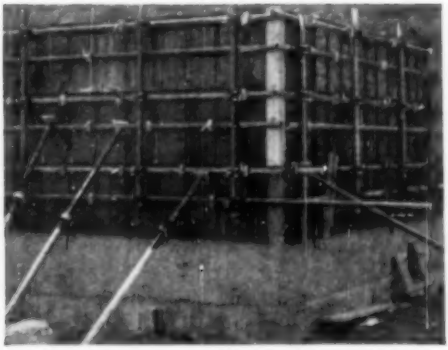

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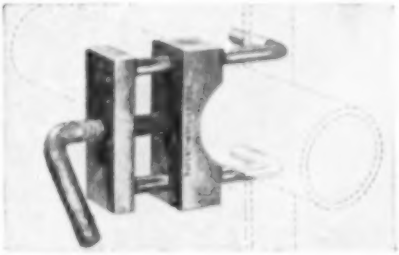

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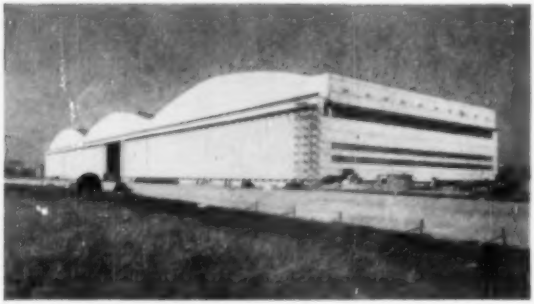

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lighting or heat insulation, spanning 18 ft. to 36 ft. transversely and 36 ft. to 72 ft. longitudinally, the average amounts of materials required per square foot of roof are 1·3 to 1·8 lb. of steel with a yield point of 16 tons per square inch and 0·16 to 0·2 cu. ft. of concrete. (4) The precast units can be lifted with ordinary equipment. (5) The temporary steel frames prevent distortion. (6) The low weight and the monolithic nature of the roof provide considerable resistance to earthquake. (7) The finished shell is without ribs, and the stress re-distribution which occurs on removal of the temporary frames produces compressive stresses at the edges and ensures efficient use of the materials under dead load only.

Method of Design.

A full-scale model has been built in Bulgaria according to the theory of Professor Wlassow.* This model had a shell 2·5 cm. (1 in.) thick without ribs. It was of spherical shape with a radius of 19 m. (62 ft. 6 in.) and was 6 m. by 18 m. (19 ft. 9 in. by 59 ft. 9 in.) in plan. It was built with four separate elements erected by means of six light steel erection frames, each of 6 m. (19 ft. 9 in.) span. When an intermediate shell was tested to destruction failure occurred at the corners and edges due to excessive shearing stresses. No damage occurred near the metal ferrules cast into the edges of the shell. The complete roof, designed for an imposed load of 130 kg. per square metre (27 lb. per square foot), was first loaded with 140 kg. per square metre (29 lb. per square foot) on one side only, and finally with a uniform load of sand of 280 kg. per square metre (60 lb. per square foot) over the entire area for five days; no cracks were visible. Gauge measurements agreed with the calculated strains.

The experience gained from this model was used in developing the writer's method, and in 1954 it was used for a storage shed about 12 m. (39 ft. 6 in.) high, which is covered by spherical shells 3 cm. (1⅛ in.) thick, without ribs, and resting on two-pinned longitudinal arches of 21 m. (69 ft.) span and transverse

Fig. 3.—Shell Elements with Stiffening Frame.

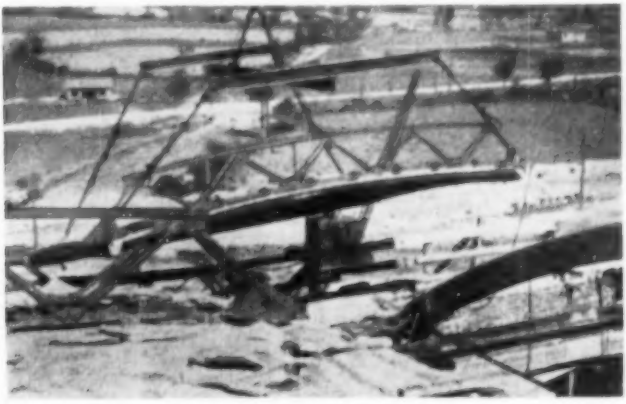


Fig. 4.—Erection of an Element.

* General Theory of Shells and its Use in Industry. (U.S.S.R. State publications of technical and theoretical literature. Moscow, 1949.)

beams 6 m. (19 ft. 8 in.) long. Each section is composed of three intermediate shell-elements and two end shell-elements, the latter joined to the transverse beams. The two-pinned arches comprise two half-arches and a steel tie rod; these were connected on timber centering. The free edges of the shell-elements were stiffened during stripping of the moulds, transporting, and erection by means of light steel frames (*Figs.* 3 and 4). During storage the shell-elements were stacked in tiers of four with the free edges supported vertically and stiffened by means of arches made from steel angles. Erection was carried out by means of a 5-tons crane.

An Unusual Staircase.

THE emergency staircase shown in *Fig.* 1 connects the first floor to the ground floor of a block of flats in Sedan, France. The treads were precast and bolted to the Z-shaped beam which was cast in-situ, as were the landings. An elevation is shown in *Fig.* 3, and in *Fig.* 2 is a detail of the reinforcement. The beam is not supported at the top, stability being provided by the base only. The architect is M. Jean de Mailly and the engineer M. André Bages. The staircase was described in a recent number of the Belgian journal "La Technique des Travaux."

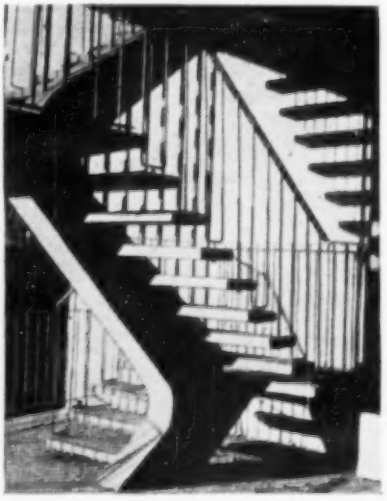


Fig. 1.

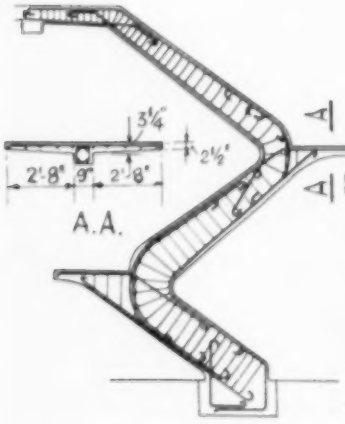


Fig. 2.

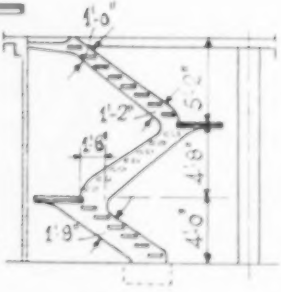
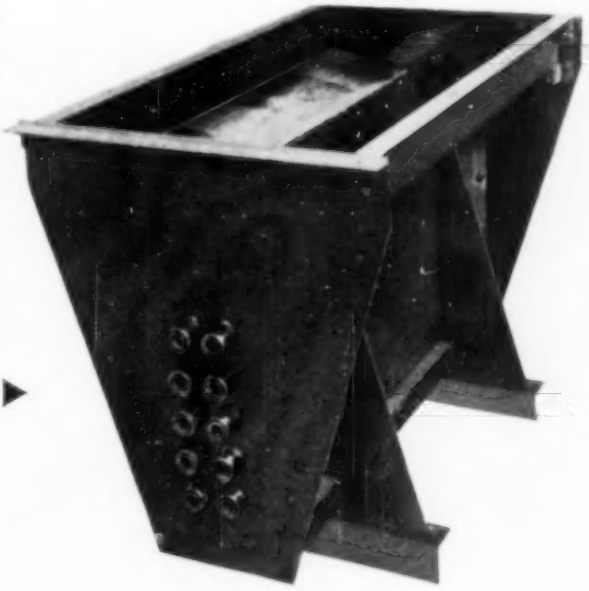


Fig. 3.

We illustrate one of a set of steel moulds that we designed and supplied to The Devon County Council. From this one set of moulds the beams were produced for Lynmouth High Street Bridge, Barbrook Bridge, and Hillsford Bridge.



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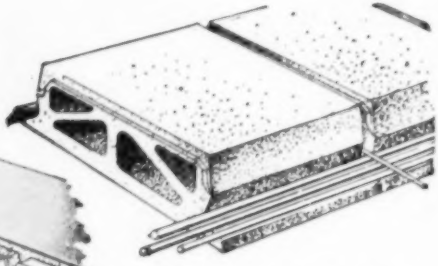
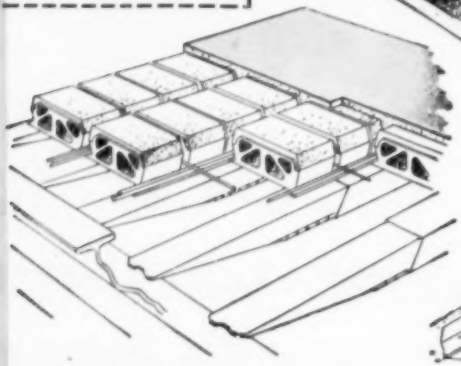
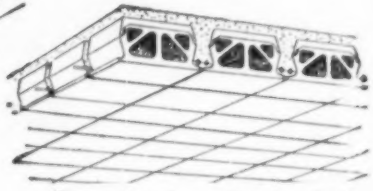


Smith's Two-Way Reinforced Floor for distribution of point loads with efficiency and economy.



Showing Two-Way Reinforcement and Hollow Concrete Blocks laid on Trianco Telescopic Centers.



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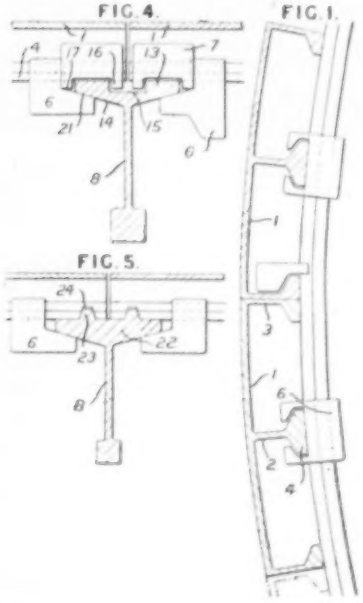
Protecting Reinforcement.

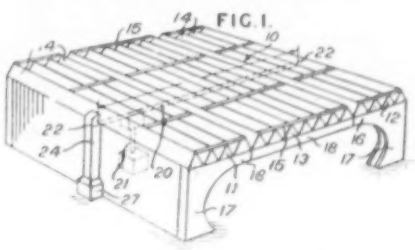
RUSTING of reinforcement is inhibited by applying thereto a cement slurry containing sodium benzoate, or by including sodium benzoate in the whole mass of concrete. The slurry may be applied by brushing or spraying. The sodium benzoate may be dissolved in the water to the extent of from 2 to 10 per cent. of sodium benzoate, or may be added as a powder to the cement which is mixed with two to three volumes of sand. Two or more coats of slurry may be applied to form a coating about $\frac{1}{8}$ in. thick which is allowed to set for 48 hours. The reinforcement may be coated either before or after it is in position.—No. 706,319. North Thames Gas Board and G. Dougill. May 10, 1951.

Shuttering for Tunnels.



SHUTTERING for concrete tunnels comprises extruded sheets (1, *Fig.* 1) of light metal with integral ribs (2, 3) each having a flanged or thickened outer end (4) in cross section, the sheets (1) being arranged edge-to-edge to form a cylindrical structure by securing them to supporting rings (8, *Fig.* 4) by means of wedge members (6). Curved profile sections (8) of light metal are detachably connected end-to-end to form a supporting ring, and centering pieces (7) immovably fixed at the ends of the ribs of adjacent sheets (1), have projections (16) which engage in a longitudinal groove (15) of the section (8), whilst projections (17) form stops for the edges of the flanges (13) of the section (8). On the flanges (4) of the ribs (2), wedges (6) are slidably arranged, their surfaces (21) engaging inclined faces (14) of the flanges (13). Instead of using centering pieces (7), the flange (22, *Fig.* 5) of the section (8) may be formed with projections (23) which engage grooves (24) in the ribs of the sheets (1).—No. 697,427. Soc. Anon. pour l'Industrie de l'Alumium September 13, 1951.

Design for Moving Loads.



IN a method of constructing buildings where a large load is required to be movable across a floor or roof which is unsupported near to the path of the load except at a perimeter point or points, the floor or roof has girder-like rigidity in the direction of the path and at least one perimeter point of the floor or roof near to the path is prestressed downwardly and rigidly connected to the ground or equivalent foundation through a strut or column to maintain the prestressed condition and also act as a rigid compression-resisting strut or column.

In an application, an airplane hangar has a roof (10) constructed in three sections (11, 12 and 13) each comprising inverted V-section main members (14) of

reinforced concrete made in situ together with interconnecting transverse beams (15) at their upper and lower edges and a crane-rail (20) for a mobile crane (21). The opposite ends of the two outer roof sections are supported upon arms (16) of pier members (17) which, with beams (18), define arched doorways at both ends of the building. At the perimeter points (22), reinforced concrete columns (24) are formed rigid at their upper ends with the adjacent roof section (11 or 12) and supported at their lower ends on removable jacks or wedges. The weight of the columns is more or less equal to the stress to be applied, and the jacks or wedges are removed so that the columns are suspended from points (22) of the roof. With the roof under such conditions of stress the lower ends of the columns are rigidly anchored to the ground, for example, by a concrete block (27).—No. 695,869. Sir E. O. Williams. March 16, 1951.

A Symposium on the Strength of Concrete Structures.

A SYMPOSIUM on the Strength of Concrete Structures, is to be held in London, from May 16 to 18, 1956. The provisional programme is as follows:

Some Aspects of Structural Loading, by M. R. Horne; Safety in Reinforced Concrete Structures, by Arne I. Johnson; Factors of Safety, by Professor A. G. Pugsley.

Strength of Concrete Members in Combined Compression and Bending; Strength of Concrete Members in Combined Bending and Torsion, by S. Armstrong; Strength of Prestressed Concrete Members, by Professor C. P. Siess; Strength of Concrete under Compound Stress, by A. J. Harris; Moment Redistribution in Continuous Beams Reinforced with Plain and Deformed Bars, by K. Hajnal-Konyi and H. E. Lewis.

Strength of Statically-indeterminate Reinforced Concrete Structures, by Professor A. L. L. Baker; Strength of Statically-indeterminate Prestressed Concrete Structures, by Y. Guyon; Strength of Continuous Prestressed Concrete Beams and Frames, by P. B. Morice and H. E. Lewis.

Strength of Concrete Walls, by A. E. Seddon; Strength of Concrete Members under Dynamic Loading, by S. C. C. Bate; Strength of Slab Deck Bridges, by P. B. Morice and G. Reynolds.

Ultimate Strength of Reinforced Concrete in American Design Practice, by E. Hognestad. Ultimate Strength Design and Building Regulations—Future British Practice, by D. D. Matthews.

Application for membership should be made to the Cement and Concrete Association, 52 Grosvenor Gardens, London, S.W.1.

Lectures on Building.

THE following lectures have been arranged by the Ministry of Works. Admission is free.

Vibration in Buildings, by R. J. Steffens. Medway College of Technology, High Street, Chatham. November 15, 7.15 p.m.

Repair of Dangerous Buildings, by F. L. Felgate. South-east London Technical College, Department of Building, Worsley Bridge Road, London, S.E.26. November 18, 7 p.m.

Dampness in Buildings, by J. P. Latham. Gas Showrooms, Osborne Street, Grimsby. November 23, 7.15 p.m.

Programming of Building Contracts, by C. N. Craig. Technical College, Queen Street, Huddersfield. November 23, 7 p.m.

Essentials of Good Concreting, by E. H. Macmillen. Gas Showrooms, Town Hall Extension, Manchester. November 24, 7.15 p.m.

Weathering and Deterioration of Concrete and Cement Renderings, by C. Hobbs. Technical College, Hopwood Lane, Halifax. November 24, 7.15 p.m.

Application of Soil Mechanics to Buildings, by A. L. Little. South Dorset Technical College, Newstead Road, Weymouth. November 29, 7 p.m.

Some views of the open-air swimming pool at the Skegness Holiday Camp. By kind permission of Messrs. Butlins Ltd.

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SITUATIONS VACANT. Reinforced concrete engineers require designers, detailers, and draughtsmen at their Keynsham (Bristol) office. Vacancies offer opportunity to work on a variety of structures, and salaries will be dependent on age, experience, etc. Previous similar experience an advantage but consideration will be given to other suitable applicants. BOX 4198, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Quantity surveyors required immediately in Westminster office for preparation of estimates, interim and final valuations of reinforced concrete work in London and suburbs. Permanent positions with prospects offered to men of proven ability. Superannuation scheme available. Alternate Saturdays. Write, stating experience, age, and salary required. All replies strictly confidential. BOX 4200, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. £850–£1000 per annum is offered to designing engineer experienced in design of reinforced concrete structures in accordance with Building Acts and district surveyors' requirements. The appointment is pensionable. Five-days' week. BOX 4205, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. Senior engineering designer, familiar with reinforced concrete construction, Codes of Practice and Byelaws, required by well-known firm with headquarters in London. The position is a responsible one attracting a salary of £900 per annum upwards, according to knowledge and experience. Pension scheme. BOX 4206, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Seventy five pounds per month and upwards, according to experience, offered for experienced designer of reinforced concrete as applied to commercial buildings. Pension scheme, and a permanent position with an old-established company in their London head office. A vacancy also exists for designer-draughtsman working under senior draughtsman, with salary from £50 per month. Reply BOX 4207, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. A.M.I.Mech.E. with some electrical and building constructional experience, or A.M.I.C.E. with mechanical and electrical experience, required for interesting position in the Middle East. Age preferably 30–35. Basic salary according to experience, plus free furnished quarters and living allowance. Apply, with full details, to BOX 4208, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

LONDON COUNTY COUNCIL

ARCHITECT'S DEPARTMENT

Vacancies for Engineering Assistants (up to £783) and Engineer Grade III (up to £945) in the Structural Engineering Division. Work includes steelwork and reinforced concrete design and detailing for Council's buildings. Particulars and application forms from Architect (AR/EK/SE/3), The County Hall, S.E.1. (1278.)

MISCELLANEOUS ADVERTISEMENTS.

(Continued from page lxii.)

DESIGN ASSISTANT WANTED

Design assistant required for Company manufacturing prestressed concrete. Variety of design in prestressed and reinforced concrete. Applicant should be familiar with the normal methods of structural analysis. Apply, giving full details and salary required, to BOX 4190, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. General foreman and section foreman required for large pile foundation work and silo construction in Turkey. Three years' contract starting January, 1956. Good salary for foremen with right experience and background. Write, giving full particulars to CHRISTIANI & NIELSEN, LTD., Romney House, Tufton Street, London, S.W.1.

SITUATION VACANT. Site agent (civil engineer) required for large pile foundation work and reinforced concrete silo construction in Turkey. Three years' contract, starting January, 1956. Good salary for civil engineer with the right experience and background. Write, giving full particulars, to CHRISTIANI & NIELSEN, LTD., Romney House, Tufton Street, London, S.W.1.

SITUATION VACANT. Architects, with large London practice, require qualified civil engineer to run engineering section (mostly reinforced concrete). Successful applicant's name will appear on notepaper, and arrangements made with him in regard to any work introduced by him. Write, in confidence, to BOX 4210, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Reinforced concrete design engineers required by consultants for varied and interesting work. Applicants should be able to take charge of a small group of designer-draughtsmen and would be expected to work without supervision. First-class salaries for right men. Apply SIR BRUCE WHITE, WOLFE BARRY & PARTNERS, 1 Lygon Place, London, S.W.1. Sloane 0431.

SITUATION VACANT. Assistant civil design engineer required for design work in connection with extensive development schemes in progress and planned. Reinforced concrete experience essential. Applicants must be capable of developing schemes and supervising their subsequent detailing and progress. Apply, stating age, experience, salary required, and when at liberty, to BOX 4211, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. THE BRITISH REINFORCED CONCRETE ENGINEERING CO., LTD., have vacancies for reinforced concrete designers and detailers, with some experience, in their Stafford, London, Liverpool, Bristol, Glasgow, Newcastle-upon-Tyne, and Leeds offices. Staff pension scheme and five-days' week. Apply in writing to CHIEF ENGINEER, Stafford.

SITUATION VACANT. Engineering assistant (structural) required by the Northern Rhodesia GOVERNMENT for one tour of three years on contract. Salary scale (including present cost-of-living allowance) £877 rising to £1171 a year. Gratuity at the rate of £100 a year. Commencing salary according to experience. Outfit allowance of £30. Free passages. Candidates, under 35 years of age, should have served a four-year apprenticeship to a structural engineer, and have had experience of the design and preparation of working drawings of reinforced concrete structures. A knowledge of structural steelwork would be an advantage. Write to the CROWN AGENTS, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience, and quote M2B/41247/CAR.

SITUATIONS VACANT. Reinforced concrete designers and draughtsmen required by Midland firm. Permanent positions, with good prospects and assistance in house accommodation. Apply in writing, giving details of age, experience, and salary required, to DEPT. P.B., BEECHAM BUILDINGS, LTD., Shipston-on-Stour, Warwickshire.

STRUCTURAL DESIGNER WANTED IN CANADA

Consulting Structural Engineers in Toronto, Canada, require experienced designer for prestressed concrete and shell design. Good background in general reinforced concrete work essential. Assisted passage, generous salary. Apply with full details of experience, qualifications and references to BOX 4213, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Recent graduates (civil engineering) required by Midland firm of reinforced concrete engineers. Permanent positions with good prospects. Apply, giving full details, to DEPT. P.B., BEECHAM BUILDINGS, LTD., Shipston-on-Stour, Warwickshire.

SITUATIONS VACANT. Estimator, and also taker-off, required by reinforced concrete contractors in Westminster. Experienced in taking-off and preparing bills of quantities. Permanent progressive positions offered to men of proven ability. Superannuation scheme available. Write, stating age, experience, and salary required (replies strictly confidential), to BOX 4209, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. Draughtsman-detailer, with at least seven years' experience of reinforced concrete required for the London office of HOLLAND & HANNEN AND CUBITTS, LTD. Staff pension, bonus and sickness schemes in operation. Please send full particulars, in confidence, to PERSONNEL MANAGER, Queen Anne's Gate, London, S.W.1.

SITUATIONS VACANT. Assistant structural engineers required with experience of reinforced concrete design. Experience of precast techniques advantageous. Salary according to experience and qualifications. Apply in writing to TECHNICAL MANAGER, THE SCOTTISH CONSTRUCTION CO., LTD., Sighthill Industrial Estate, Edinburgh.

SITUATION VACANT. Structural engineer, fully experienced in the design of reinforced concrete structures of all types, required by consulting engineers. Five-days' week, pension scheme, new and modern office in Central London. Commencing salary £1250 per annum. BOX 4214, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. Reinforced concrete designer-detailer required by consulting engineer. Commencing salary £850–£950 per annum, according to experience. Five-days' week, pension scheme, modern office in Central London. BOX 4215, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Consulting engineers engaged on colliery surface installations and other interesting industrial structures, require detailer-draughtsmen. Knowledge of design desirable but not essential. Good prospects for suitable applicants, and opportunities for occasional site visits. Five-days' week. Write, stating age, experience, and salary required, to J. C. HUGHES & PARTNERS, 83 Gloucester Place, London, W.1.

SITUATIONS VACANT. Civil and structural engineering assistants experienced in reinforced concrete and/or structural steel required. The work is varied and offers scope for initiative. The vacancies are for experienced staff with recognised qualifications and detailers preferably with some design experience. Five days' week. Pension scheme. Good salaries will be offered to suitable applicants, who should state experience and salary required to ENGINEERING DEPARTMENT, FARMER & DARK, Romney House, Tufton Street, London, S.W.1.

SITUATIONS VACANT. Design assistant and designer-draughtsmen required for the structural engineer's office of an expanding company manufacturing prestressed concrete. Applicants should be familiar with the normal

MISCELLANEOUS ADVERTISEMENTS.

(*Continued from page lxiii.*)

methods of structural analysis, and should have experience in design detailing. Knowledge of prestress an advantage. Salary commensurate with experience. Apply, giving full details of experience and education, to CHARLTON CONCRETE CO. LTD., 7A Pulteney Street, Bath.

SITUATION VACANT. Civil engineering assistant, with experience in dock and harbour design, required by consulting engineers in London. A.M.I.C.E. qualifications desirable but not essential. Salary range from £750 upwards, based on experience in design generally. Box 4216, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Reinforced concrete draughtsmen required with some knowledge of design. Apply, giving experience, age, and salary required, to HOLST & CO., LTD., 10 Waddington Street, Durham City.

SITUATION VACANT. Benford Limited, engineers and manufacturers of concrete mixers, weighbatchers, Diesel dumpers and power barrows, have a vacancy for an additional senior mechanical design draughtsman. The commencing remuneration is not less than £1,500 per annum. The post is a permanent one, and a pension scheme is in operation. Applications will be treated in strictest confidence, and should be made in writing and addressed to MR. P. WEBB, GENERAL MANAGER, BENFORD LTD., the Cape, Warwick, and marked "Personal."

THE UNIVERSITY OF LEEDS

DEPARTMENT OF CIVIL ENGINEERING

Applications are invited for appointment as Lecturer in Civil Engineering at a salary on the scale £650 × £50 — £1,350 a year, according to qualifications and experience. Candidates should have an honours degree and practical experience in Public Works Engineering. Some experience in Public Health and/or Traffic Engineering will be an advantage. Applications (three copies) stating date of birth, qualifications and experience, together with the names of three referees, should reach the Registrar, The University, Leeds, 2 (from whom further particulars may be obtained) not later than 2nd January, 1956.

SITUATIONS VACANT. Draughtsmen detailers required for London office of consulting engineers. Some drawing-office experience in reinforced concrete work essential. Five-days' week, pension scheme, luncheon and sports club. Apply in writing, with full particulars of age, experience, and salary required to RENDEL, PALMER & TRITTON, 125 Victoria Street, London, S.W.1.

SITUATION VACANT. An old-established company require a keen man as assistant to manager of estimating and draughtsmen's department, specialising in concrete and glass construction. Knowledge of concrete design plus ability to handle technical correspondence are essential qualifications. Five-days' week. Non-contributive pension scheme. Applications to give age, experience, with full details of position or positions held during the last five years. Box 4219, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. Contracts manager. A well-established London firm, particularly interested in all forms of concrete construction and having large interesting contracts in various parts of the country, require the services of a first-class contracts manager. Applicants should have good technical knowledge (preferably holding a qualification) and administrative ability, the energy and drive necessary to maintain good standards of work and performance at competitive costs, together with the interest and keenness to keep abreast of new methods and equipment in the industry. A generous salary will be paid reflecting the responsibilities of the position, which affords the opportunity for promotion and salary increases in recognition of good endeavour and results. The firm operates a pension and insurance scheme. Full details of training and career should be given, including present position and employer, together with salary range required. References will be taken up by agreement only, following interview. Present staff have been informed of this advertisement. Box 4220 CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Required. Detailers experienced in reinforced concrete work (also some steelwork). High salaries for right men. Box 4217, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. Production foreman required to take control of the output of a growing precast concrete concern. Must be good organiser, and have knowledge of production methods. Practical knowledge an advantage, but not altogether essential. Apply to KINGSBURY CONCRETE CO. LTD., R.O.F., near Kettford, or C. R. Price, Kingsbury Road, London, N.W.9.

SITUATION WANTED. Engineer, A.M.I.C.E., 35, Cambridge honours graduate, nine years civil engineering including reinforced and prestressed concrete and atomic energy, five years' electrical experience, requires appointment about January. New resident south of Manchester. Box 4218, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

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FOR SALE. New M.S. Reinforcing rods from stock. 100 tons of ⅜-in., ½-in., and ⅝-in. diameters. Random lengths up to 40 ft. French rolled. Ribbed pattern to ensure improved bond. Inquiries to COX & DANKS, LTD., Scapa House, Park Royal Road, London, N.W.10.

FOR SALE. Steel tubes and fittings, sections, strips, blanks, etc. List on request. E. STEPHENS & SON, LTD., Bath Street, London, E.C.1. Clerkenwell 1731.

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FOR HIRE. Lattice steel erection masts (light and heavy), 30 ft. to 150 ft. high, for immediate hire. BELLMAN'S, 21 Hobart House, Grosvenor Place, London, S.W.1.

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